Dupp AG: A new vision for the vehicle recycling business

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Abstract

This thesis provides and analyzes a business case of a German Tier 1 automotive supplier which was faced with the decision of whether to invest in a large-scale vehicle recycling plant. With the objective to make a well-founded decision, a quantitative and qualitative analysis was presented in the teaching note section. Business model economics and profitability were assessed using a discounted cash flow (DCF) analysis that was tested for robustness with sensitivity metrics. The qualitative analysis was based on the current state of literature on the influences of first-mover strategies and plant location decisions, as addressed in the literature review section. Therefore, not only the go/no-go investment decision, but also potential alternative strategies regarding timing and location of the plant were evaluated. The case analysis further explored the opportunity for corporations to leverage the circular economy (CE) to build business models supporting this trend while being profitable – a topic also included in the literature review chapter. Lastly, the thesis detailed how a profitable vehicle recycling business in Europe could work and an investment was recommended.

Key Words: Circular Economy, Recycling, First-mover, Plant location, Automotive industry

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Resumo

Esta tese fornece e analisa um estudo de caso de um fornecedor automóvel alemão de nível 1 que se depara com a decisão de investir ou não numa fábrica de reciclagem de veículos em grande escala. Com o objectivo de tomar uma decisão bem fundamentada, foi realizada uma análise quantitativa e qualitativa, apresentadas na secção Notas de Aula. A lógica económica e a rentabilidade do modelo de negócio foram avaliadas utilizando uma análise DCF que foi testada quanto à robustez com métricas de sensibilidade. A análise qualitativa baseou-se no estado actual da literatura sobre a influência das estratégias de antecipação e de decisão de localização de instalações, tal como abordadas na secção da Revisão de Literatura. Portanto, não só é avaliada a decisão de investir ou não, mas também as potenciais estratégias alternativas no que diz respeito ao calendário e à localização da fábrica. A análise do caso explorou mais desenvolvidamente a oportunidade de as empresas alavancarem a economia circular para construírem modelos de negócio rentáveis baseados nesta tendência – um tópico também abordado na Revisão de Literatura. Finalmente, a tese detalha como poderia funcionar um negócio rentável de reciclagem de veículos na Europa e recomenda um investimento.

Palavras-chave: Economia Circular, Reciclagem, Antecipação, Localização de Instalações, Indústria Automóvel

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CASE

Frank Bauer, Vice President and Head of Corporate Development at Dupp AG (Dupp), arrived at the office early the morning of March 14, 2022. After several months of home office, he was excited to be back at Dupp headquarters outside of Stuttgart, Germany. Around the office, he still found the marketing brochures celebrating Dupp's 130th anniversary in 2021. As his coffee brewed, he skimmed through the brochure: what began as a metal shop for roof flashing by Paul Dupp in 1891, became a famous brand name for chemical surface treatment and dip coating in the 1950s and 60s, and a leader in Automotive Paint Shop technology.

That morning, Bauer was sipping his coffee and checking his calendar to prepare for the day, when he received an unexpected call from Massimo Bellegri, the CEO of CBM S.p.a., an Italian subsidiary of Dupp. Bauer was surprised, not only by the phone call, but also by the matter itself. The CBM CEO had developed a completely new business model: large-scale car recycling. Since CBM did not have the financial means to build such a recycling plant close to Milan alone, it looked to the parent group for support.

It was clear from the phone call that, despite being easy to replicate, this venture could be a novelty in the industry if brought to market quickly, and could be a great fit with the trends of sustainability and circular economy. However, with a tightened budget due to the COVID-19 pandemic, the time might not be right for high-risk investments. Dupp's revenue dropped by over 15% from 3.92 billion EUR in 2019 to 3.32 billion EUR in 2020 and recovered just slightly to 3.54 billion EUR in 2021. Bauer was therefore unsure how to present the opportunity to his boss, Dr. Jürgen Walther, the Deputy CEO of Dupp since 2017, who had just taken over as CEO at the beginning of 2022. With mounting time pressure, he knew that he had to decide on the viability of this investment and whether this business idea had a foundation.

Company Background

Organic Growth in the Early Years

What was to become a major automotive and industrial company began as a simple tin business in the 19th century. In 1890, Paul Dupp, then only 24 years old, set up shop as a tinsmith in Stuttgart, Germany, building small-scale orders such as stove pipes, gutters and roofs. His son, Otto, took the helm in 1932 and led the company in the development of sheet metal products. As sheet metal grew in popularity, forcing out cast iron, Dupp supplied containers, machine tool tables and other products.

During World War II, Germany called on Dupp to produce materials for the war effort; many of the items were vehicle parts that needed to be primed for the factories. This was Dupp's first experience with surface treatment, a service that would become fundamental to its business.

With Dupp's origin in the Stuttgart region, the company headquarters had always been close to major automotive players such as Mercedes-Benz, Porsche, and Bosch. The growing automotive sector in other regions of Germany along with the many world-famous original equipment manufacturer (OEM) brands acted as a springboard for Dupp’s business.

Inorganic Growth after Going Public

Dupp went public in 1989 and took over application technology specialist Bohr. This enabled Dupp to significantly expand its core competency – the supply of turnkey paint shops – thus becoming the world market leader in this business. With the turn of the millennium, Dupp rapidly grew through acquisitions. In quick succession, it took over service company Primer, measuring technology group Schank and French plant engineering firm Abstorm Automation. In search for new opportunities for expansion, Dupp acquired Hemeg in 2014, a supplier of woodworking technology. Many other acquisitions would follow in fields such as Internet of Things (IoT) solutions, environmental systems for industrial exhaust-air purification, automated assembly, and functional test systems.

Business Segments

Dupp and its subsidiaries operated in five major business segments. The Dupp brand itself carried three segments, namely Paint & Final Assembly Systems (PFS) (~35% of revenue), Application Technology (APT) (~15% of revenue) and Clean Technology Systems (CTS) (~10% of revenue). Within PFS, Dupp built and optimized paint shops and final assembly lines largely for the automotive industry. Dupp provided OEMs the complete paint process in large turnkey projects including dip coating technology, oven systems and automated spray booths. Dupp went from paint shops to expanding along the manufacturing process to final assembly systems, including overhead and floor conveyors and systems for marriage, filling and end-of-line testing. With this engineering expertise, Dupp decided to further expand its offering to consulting services from management level, e.g. market, production and digital strategies, all the way to operating level, such as factory planning, and process & manufacturing engineering. The APT division focused on the paint application itself, gluing (e.g. windshields), seam sealing technology and other products for industrial painting. The smallest segment, CTS, sold systems for air and noise pollution control, coating lines for battery electrodes and systems for solvent recovery. Most CTS sales came from exhaust air purification systems, which were primarily sold to the chemical and pharmaceutical sectors.

With the acquisitions of Schank and Hemeg in 2000 and 2014 respectively, Dupp expanded into two further segments: Measuring & Process Systems (~5% of revenue) and Woodworking Machinery & Systems (~35% of revenue). Schank had a strong focus on balancing and diagnostic technology, e.g. for wheels, tires and other rotating or oscillating parts. Hemeg provided machinery and complete plants for the woodworking industry. This included large turnkey production lines for prefabricated timber houses as well as machinery for furniture and components such as flooring, windows, and staircases.

Global Footprint & Finance

Dupp ran 116 locations in 33 countries. By 2021, 10.569 employees were located in Europe, 3.492 in Asia, 2.229 in the Americas, 189 in Africa and 46 in Australia. Approximately 40% of sales were generated in Europe, of which over 15% came from Germany. The Americas generated some 28%, China around 21%, while Asia, Africa and Australia accounted for over 10% (*Exhibit 1*). The corporation's operation achieved rather constant profitability margins in pre-COVID years. Between 2015 and 2019, the EBITDA margin of Dupp fluctuated between 9,1% and 9,7%, whereas the EBIT margin ranged from 6,8% to 7,2% in the same time frame. The pandemic in 2020 halved the EBIT margin, which was expected to recover by 2022/23.

Industry Background

Automotive Paint and Final Assembly Tier 1 Suppliers

Dupp's main business segment of automotive PFS had been a rather consolidated market, at least in the scope of large global players that executed sizeable turnkey projects for the big automotive OEMs and customers of other industries. Dupp and Eisenmann SE from Germany, as well as SCIVIC (China Automobile Industry Engineering Corporation) from China, dominated the market.

Founded in 1959 in Tianjin, China, SCIVIC joined forces with the Fifth Institute of Project Planning & Research of China Machinery Industry (FIPPR) and formed the Automotive Engineering Corporation (AE Corp.), which employed 3.800 people and accounted for order income of about 2 billion EUR. AE Corp. was part of the Chinese SINOMACH Group, which employed around 180.000 people in over 170 countries with a turnover of over 38 billion EUR (AE Industry, 2022).

Eisenmann SE was Dupp's closest competitor and offered a similar product and service portfolio in conveyor systems, paint shops, final assembly, and digital services. Eisenmann also had a large international footprint and supplied Tesla, Lamborghini, and Daimler, to name a few. However, Eisenmann, which had 3.000 employees at 27 locations in 15 countries and generated annual revenues of over 800 million EUR, filed for insolvency in 2019. The insolvency came as large car manufacturers such as Daimler had issued profit warnings, triggered by a downturn in auto demand. This chain of events was a clear example of diminishing margins caused by the extreme price pressure on suppliers in the automotive industry (Reuters, 2019).

The Eisenmann insolvency casted a shadow on the entire automotive industry. Production had been down 5% worldwide. Even China, the largest automotive market in the world, experienced decline. In the first half of 2019, primary car market sales fell by 14% year-over-year. Opel announced it was cutting 1.100 jobs; Nissan 12.500; GM 14.000, Tesla 3.000, Jaguar 4.500, VW 7.000, and Ford 12.000 including five plant closures in Europe by the end of 2029 (Gaisenkersting, 2019).

The number of passenger vehicles produced worldwide had already declined from 73.457.000 in 2017 to 67.149.000 in 2019 and the beginning of the COVID-19 pandemic only worsened the situation for automotive industry players. In 2020, car production plummeted again by 17% compared to 2019 (*Exhibit 2*). Consumers deferred their spending, which led to reduced demand for passenger vehicles and forced many factories to shut down.

Automotive Industry E-Mobility Trend

Towards the end of the 2010s, the switch to e-mobility provided new growth areas for the automotive industry. OEMs saw huge opportunities to sell new battery electric or hybrid vehicles and extend their business to the supply of energy and other services. Suppliers such as Dupp benefitted by providing machinery to adapt existing manufacturing lines to the production of electric vehicles (EVs) and batteries. In addition, many new car manufacturing startups, such as Tesla, Lucid and Rivian in the US or Nio in China were expected to build new greenfield car factories, which had been rare among established OEMs in previous years. This gave Dupp an additional opportunity to equip these new manufacturing plants.

Tesla’s market share continued to grow, and in 2016 for the launch of the Model 3, Tesla published an article in their marketing blog titled: “The Week that Electric Vehicles Went Mainstream”. This was not a marketing gimmick. The car managed to get over 325.000 pre-bookings, which translated to 14 billion USD in future sales and marked the single largest one week launch of any product in history (Jocelyn and Biagi, 2021).

Next to the “Tesla Effect”, government efforts to control climate change were one of the main drivers of the global EV market. After committing to international climate goals, the mobility sector was a big industry to target with subsidies or environmental penalty payments. There were several government incentives used to persuade individuals to buy EVs: tax exemptions in various forms, grants and subsidies (*Exhibit 3*).

The high costs associated with lithium-ion battery cells had been one of the main obstacles to large-scale EV adoption since they typically led to higher purchase prices for EVs than for comparable internal combustion engine (ICE) vehicles. However, the cost of battery packs used in EVs fell substantially. According to a 2020 study conducted by Bloomberg New Energy Finance, battery prices dropped from a global average of 600 EUR per kWh in 2010 to 139 EUR per kWh in 2019, with prices further expected to fall (*Exhibit 4*).

EV Battery Recycling

The beginning of the e-mobility trend was accompanied by a boom in development and manufacturing of EV batteries. As the demand for batteries skyrocketed, so did the demand for related raw materials. The “Lithium Triangle” in South America and cobalt mining in the DR

Congo were two examples of regions suddenly heavily exploited for the extraction of minerals essential to the state-of-the-art Li-ion battery production during that time.

Three factors soon made battery recycling a priority for OEMs, investors, and entrepreneurs. Firstly, the recycling of valuable and scarce resources from end-of-life batteries would ease the exploitation of mines in Africa, South America, and Australia. The re-use of raw materials was crucial to establishing a sustainable supply chain and putting an end to or reducing the environmental and labor impacts on local communities living and working in the mines.

Secondly, political and legislative pressure pushed the industry to find a more sustainable source of metals for batteries. This was brought sharply back into focus when the Indonesian Government banned the export of nickel ore at the end of October 2020 (Person and Home, 2022). The EU Commission also pushed for a larger proportion of recycled materials in the future through its new Battery Directive (European Parliament, 2022).

Thirdly, it was apparent that the battery was by far the most valuable part of EVs. The possibility of extracting these metals from the battery packs at very high efficiency levels translated to business potential, rather than a pure "green" initiative. The business of battery recycling could achieve attractive EBIT margins of about 15%, especially in regions with cheaper factors of production (*Exhibit 5 & 6*).

It was expected that by 2030, battery-operated EVs and plug-in hybrid models would account for around 20% of vehicles globally. Additionally, with a lifetime of at least 10 years, investments in battery recycling were mainly targeted towards the future, when the first wave of EVs brought to market would near end-of-life (Jocelyn and Biagi, 2021).

While the high-value metals in batteries drew attention to recycling potential, there was little attention paid to recycling traditional ICE vehicles, which would reach end-of-life much sooner as consumers switched to electric mobility.

The Business Model of "The Recycling Factory"

For Dupp, building a large-scale vehicle recycling business meant differentiating itself from small-scale garage workshops, automotive scrap yards, and car salvage lots and competing with overseas price pressure. The Recycling Factory (TRF) differentiated itself, not by focusing on individuals selling their old cars, but by buying in large quantities directly from OEMs. Large quantities were needed to make such a venture viable and only OEMs could provide the input in the units needed. In return, Dupp would not only operate the disassembly facility, but would also manage logistics services, bringing all available vehicles to TRF, thus making the offer as attractive to OEMs as possible. Since higher logistics costs reduced profit margins, the location of TRF was even more crucial for the success of the business model.

Bellegri and a team from the Dupp headquarters developed a new disassembly process, maximizing automation and standardized processes. The setup was similar to a traditional conveyor belt system, the difference being that vehicle manufacturing steps had been reversed. The two main opportunities to generate revenue from this operation were: extracting spare parts in good condition to be re-sold on the secondary market; and further separating and shredding raw materials for resale. However, the initial business case was focused on extracting basic materials only. The spare parts business was a secondary opportunity that could be added later depending on the vehicle supply and condition.

The disassembly and material processing of vehicles would inevitably be highly manual and labor-intensive. Despite efforts to standardize and automate the process, it was difficult to leverage a similar level of digital and robotized handling as used in automotive manufacturing, since the disassembly line of TRF had to be suitable for all brands, models, and types of vehicles.

After crucial vehicle parts were removed, the remaining shell would then be crushed and shredded to facilitate transportation and further processing. The metal would be sold, for example to steel mills, for recycling.

Supply of Vehicles

To ensure a constant supply for TRF, Dupp was dependent on OEM partnerships. Since Bellegri had close ties with FCA, (Fiat Chrysler Automotive; also known as Stellantis after the merger with the PSA Group in 2021) he was able to secure a deal with the Italy-based car manufacturer for an input of approximately 10.000 vehicles in the first year to validate the business before scaling.

However, when Bellegri and his team pitched the idea to other automotive OEMs in early 2022, they were not able to secure a buy-in for pipeline-filling supplier contracts. Even though Dupp had great relationships in the industry and was able to, for example, present their venture to Ola

Källenius, who was the Chairman of the Management Board of Mercedes-Benz, the recent developments in the secondary car market made it difficult to convince an OEM to commit to a large-scale contract. The increase of electrification meant that end-of-life vehicles became increasingly more valuable since car batteries contained precious metals and could effectively be recycled. OEMs were aware of this, meaning that they were reluctant to give away old vehicles. Major car manufacturers were planning their own investment in battery recycling and were in the process of testing new business models in which passenger vehicles could be leased for their lifetime, rather than simply sold. This would allow OEMs to easily secure access to end-of-life vehicles and to recycle the valuable EV batteries in their own facilities. Although these ideas were only in the planning stage at the beginning of 2022, the future was clear. During the exchange with Källenius, the Mercedes CEO said: "I will discuss this opportunity internally, but can guarantee you already, that we will not give away our EVs."

In addition, the COVID-19 pandemic led to a significant decrease in consumer spending, especially on expensive and non-essential purchases such as cars. This meant that in the years 2020 to 2022, there were already less end-of-life vehicles on the market since people were keeping their cars longer or purchasing secondhand cars to reduce spending. With a lack of new cars from auto plants, (due to closed down manufacturing lines during the pandemic) and consumers more cautious of their spending, used car sales and prices soared. On top of that, global supply chain shortages hit the automotive industry in 2021. As a result of these two economic factors, secondary car market prices rose by over 25% between 2019 and 2021 (*Exhibit 7*).

Expansion & Competitor Risk

Due to the lack of propriety technology that could be patented within the recycling process, TRF had little opportunity to distinguish itself from future competition. Speed to market was thought to be crucial to the endeavor. On one hand, TRF had to be tested on a small scale in a "proof of concept" phase. However, Bauer was convinced that the business had to scale quickly in order to turn a profit. From an international standpoint, it had to expand as quickly as possible before competitors could copy the business model and cover other geographies. Bauer was confident: "In this case the 'fast followers' will not be at an advantage, rather the first movers will take the cake."

Business Model Economics

The profitability of the business was based on many variables and unknowns. Due to the high labor intensity, TRF would benefit from having facilities in countries with low wage levels. However, a major trade-off regarding the location was the cost of logistics to transport all the vehicles from their point of origin to the facility. Most end-of-life vehicles were located in developed countries since there were more cars per capita, individuals replaced their vehicles more often, and there were larger enterprises with considerable fleets; these developed countries were therefore attractive as TRF locations. On the other hand, less developed countries offered a more attractive cost structure for operations.

As the world switched to electric mobility and political incentives further enforced the switch from ICE vehicles, this "old generation" of vehicles was the input Dupp was looking for. Nevertheless, Bauer knew that the tremendous value of the automotive recycling business lay in EV batteries and this segment could also be the future of TRF.

The operating model of TRF was uncertain as a result of fluctuating raw material prices on the world market, which made it difficult for Bauer to evaluate the robustness of the business. In traditional ICE vehicles, the majority of raw materials were steel and iron, followed by polymer materials and other light metals and alloys. Between 2011 and 2020, prices per ton for steel scrap in Germany were as high as 318 EUR in 2011, and as low as 168 EUR in 2016 (*Exhibit 8*). It was difficult to calculate a business case based on materials that fluctuated by over 45% in price over a rather short period of time. Looking toward the future with EVs included in the calculation, the scenario became even more unclear since prices for raw materials crucial to battery production – cobalt, lithium and nickel – had boomed following the industrial shift. However, prices had plummeted again due to overproduction since the new demand attracted capital investment into the supply of these metals. Between 2018 and 2020, the price for lithium fell by over 50% as a result of China, the dominant force behind lithium pricing, which continued to export internationally, leading to the oversupply of lithium. By the end of 2021 and early 2022, the price of lithium had increased back to 2018 levels (*Exhibit 9*). In the end, a business dependent on the price of raw materials was not a safe bet.

The cost and revenue breakdown estimated by Bauer and Bellegri for TRF was set up as follows. On the cost side, old vehicles had to be purchased and transported to the plant; labor for TRF had to be paid; the factory would depreciate over the years; and costs would arise through marketing, sales, and administrative functions such as HR, IT or Finance (*Exhibit 10*).

On the sales side, revenue would be generated by selling steel from the vehicle frames, the catalyst (containing valuable precious metals), the engine, the aluminum and other smaller volumes of material (*Exhibit 11*).

The plan was to build a facility, owned 50% by Dupp and 50% by CBM, that could disassemble 120.000 vehicles per year at full capacity with a ramp-up plan of doing only little testing at the end of 2022, operating at 65% capacity in 2023 and at full capacity thereafter.

Capital expenditures would arise for the building, machinery and other production equipment, on-site logistics, and for office facilities (*Exhibit 12*). In addition, one could assume that another half a million euros in CapEx would be invested from 2023 onwards, simply as an assumption of ongoing CapEx requirements that would arise along the way but could not be specifically identified from the start. Since the plant would only run at testing levels in 2022, the investment in systems, machinery and other production equipment would be split into half the amount invested in 2022 and the other half in 2023. The building was assumed to have a lifetime of 35 years, the systems, machinery, and other equipment a lifetime of 8 years and other CapEx investment a lifetime of 6 years. The depreciation was expected to be linear and the depreciation value for 2026ff was estimated at 1.354.541 EUR.

Furthermore, estimates for working capital were created by Bauer and Bellegri (*Exhibit 13*), the WACC was calculated at 8,5% for 2022-2025 and 6,75% for 2026ff and the corporate tax rate was set at 24%.

Marketing and Sustainability

The business case had to be financially viable, however there was more than just financial gain to consider. The mega-trend of sustainability was fundamentally changing investment decisions of companies as well as credit and funding decisions of investors.

Increasing adoption of the triple bottom line approach was accompanied by a movement towards sustainable and holistic corporate decision making. The assessment and management of a firm's performance gradually phased-in the social impacts of business activities, such as externalities and human well-being. Businesses were increasingly competing with one another based on their value to society, rather than only financial performance.

The triple bottom line was continuously adopted by investors, who started to consider Environmental, Social and Governance (ESG) factors. Investment firms started a major strategic shift by including sustainability criteria to assess firms (HEC, 2020). Globally, regulators, insurers, and central banks were introducing tightened measures to reduce the environmental impact of corporate entities (Capgemini Research Institute, 2020).

TRF was a great asset to ensure continued access to investor capital and preparedness for future sustainability reports and measures. In addition to sustainability reporting, TRF could also be leveraged in marketing to influence brand perception. Dupp would be able to create an impactful public statement by creating a profitable business and significantly improving the sustainability of the industry. Helping the industry transition to EVs through their new battery assembly systems while also disassembling "old generation" vehicles could be written in Dupp's history books.

The Decision

Bauer had to decide whether to promote TRF and support Bellegri and his venture with a proposal to Walther and a buy-in of the whole group, or to inform Bellegri that his idea was not the investment that Dupp was looking for. In his perspective, the strategic decision to invest or not was linked to three major questions.

1) Was the market attractive to enter? Circular supply chains and large-scale recycling was thought to be at a tipping point, which was triggered by global efforts towards sustainability. However, such businesses were relatively unestablished, and the profitability of the business model had yet to be proven, which made the answer to this question ambiguous.
2) Would this venture be profitable in the medium-term? This could be likely if the high initial investment in a facility did not offset future returns. Due to the highly fluctuating economics of the business case, this question too, was difficult to answer.
3) Was TRF a good investment in 2022, and was Italy the right place to start? Bauer saw an opportunity in the corporate fit as being the "best parent" for a vehicle recycling business. However, there was doubt whether the timing – still recovering from the pandemic – was right and whether other locations than Italy might be more favorable for such a venture.

LITERATURE REVIEW

This chapter will address three overarching topics related to the issues of the case. Firstly, the circular economy (CE) and how the pursuit of circular business models and more general sustainability efforts can benefit a company or form the basis of a new venture will be investigated. Additionally, the impact of such measures on company performance, customer perception and investor attraction will be explored. The importance of supply chain independence and local sourcing enabled through CE will also be analyzed as a tool to minimize supply chain risk.

Secondly, factors of the first-mover advantage will be analyzed to determine its importance and effectiveness, since the business case was dependent on fast market penetration. The circumstances under which a follower strategy would be more advantageous and how companies can leverage and build market entry barriers to successfully protect their ventures will also be examined.

Lastly, the factors that should be considered during a geographic choice of plant location will be discussed with a focus on choosing a strategic location for a large greenfield investment.

Circular Economy

CE is a system based on energy and materials, creating a “closed-loop cycle” with limited waste of material and energy while sustaining environmental health and economic, social, and technical progress (Geng et al., 2009; Franklin-Johnson, Figge, and Canning, 2016), therefore decoupling economic prosperity from the use of natural resources (Eijk, 2015). Although CE was initially based on the “3R” principle of reduction, reuse and recycling (Yuan, Bi, and Moriguichi, 2008), it has been redefined to include recover (Kim and Goyal, 2011; Govindan, Jha, and Garg, 2015), redesign (Lu, Tsai, and Chen, 2012; Ying and Li-jun, 2012) and remanufacture (Dowlatshahi, 2005; Wu et al., 2015; Diaz and Marsillac, 2016), thus the “6Rs”.

The principle of reduction refers to limiting actual consumption, meaning what is not produced can never become waste. No matter how “green” products may be, they will have an environmental impact throughout their life cycle. Reuse is the practice of using items for as long as possible and maintaining them to lengthen their life. Why put something to waste if it is not broken? If one can no longer use a product, there will still be someone who can benefit from it and reuse it. If a product and its parts are no longer of functional use, recycling is used to break down the product into its original resources; these can then be used to construct another product (Yuan, Bi, and Moriguichi, 2008).

The activity of redesign refers to using components and materials of an old product in a new product, which was specifically restructured to use old components while remaining efficient in its usage. Additionally, design plays a large role in minimizing production waste (Lu, Tsai, and Chen, 2012; Ying and Li-jun, 2012). Remanufacturing refers to restoring a product to a like-new state while using as few components and parts as possible throughout the process. The components and parts used in the restoration of said product are already used, creating a product without loss of original functions (Dowlatshahi, 2005; Wu et al., 2015; Diaz and Marsillac, 2016). Recovery is the "last resort" of the circular economy since it is usually not very efficient. If a product is impossible to recycle or the basic resources are not wanted or needed, recovery refers to extracting the energy back either through burning, biological or chemical processes (Kim and Goyal, 2011; Govindan, Jha, and Garg, 2015).

Next to limiting resource and energy consumption and environmental harm, one of the main advantages of recycling material-heavy products such as vehicles, is the decreased price risk for raw materials within the circular economy loop (Gerner et al., 2005). A system with access to recycled raw materials becomes more independent from volatile global resource prices (Govindan and Hasanagic, 2018). In general, price volatility leads to greater uncertainty and therefore reduced business activity. Enterprises may be unwilling to handle price risk and business models may lose attractiveness when considering purchase price volatility. Businesses that operate under the current global material market spend a lot of money and effort in hedging resource prices which could be reduced or avoided within a CE environment. Additionally, a system where the manufacturer can retrieve part of a product's value back at its end-of-life, can price this into the product's cost. In combination with reduced hedging efforts, these savings can be passed on to customers or kept within the organization to increase margins. These savings represent an improved cost structure (De los Rios and Charnley, 2017).

CE systems further reduce the overall supply risk, i.e. risk of supply chain disruption (Winn and Pogutz, 2013). The less virgin supply and the more recycled materials that can be used, the more local and safe the supply chain loop becomes. The closed-loop view on supply chains includes not only forward-movement via the value chain to the end customer, but also the reverse flow of end products (Souza, 2012). These reverse efforts in logistics and recycling are crucial for ecological supply chains (Gunasekaran and Spalanzani, 2012) and they raise questions to the extent of centralization in the collection process, recycling facilities and whether resource recovery can be integrated or outsourced (Mitra, 2014).

In Europe, CE can enable the "reduction of primary material consumption by 32% by 2030 and 53% by 2050, compared [to 2015 levels]." This also relates to the pricing matter since interruptions in global material supply chains usually result in significant price impacts (Ellen MacArthur Foundation, 2015). Most geographical areas are dependent on raw material or commodity imports; the EU imports 6x the amount of basic materials and natural resources that it exports. From an economic and a geopolitical standpoint, reduced dependencies on imports can be advantageous for businesses, countries, and broader economic partnerships. Where currently very few companies control material flows worldwide, e.g. Vitol, Glencore, Trafigura, under a CE system, many more decentralized operators provide alternative material sources. Furthermore, local provision of recycled material reduces the externalities of long-distance supply chains. Metals that can be recycled and reused within Europe for example, must not be sourced and shipped from other continents, saving on costs and energy in transport (Ellen MacArthur Foundation, 2015). One must also take into account the efficiency of the recycling process and the efficiency with regard to energy when sourcing locally rather than abroad.

The execution of CE initiatives represents a preventative measure for continuous regulatory changes as well as a competitive advantage in advancing regulation (De los Rios and Charnley, 2017). This is especially true in the EU where environmental regulation has become increasingly stringent with, for example, the introduction of carbon prices, emissions trade schemes, and taxes. "Since 2009, the number of climate change laws has increased by 66%, from 300 to 500." (Ellen MacArthur Foundation, 2015). To gain competitive advantage, companies can anticipate and adapt to future changes to laws and regulations. For example, sourcing recycled material early-on and establishing supplier connections can be valuable when regulators impose a strict minimum share of recycled material to be sourced. In combination with eventual growing carbon prices, CE sources will become even more price competitive.

CE and other environmental initiatives are influencing firms' capital attraction (Dewick et al., 2020). Banks and other investors are increasingly interested in opportunities that CE has to offer (Ellen MacArthur Foundation, 2017; Geissdoerfer, Savaget, Bocken, & Hultink, 2017). Even the World Bank's agenda progresses towards the sustainable development goals and aims to support meeting the Paris Climate Agreement. A total of 130 banks from 49 countries (1/3 of global assets) signed the United Nations Principles for Responsible Banking in 2019, aiming to actively transition from linear to circular production (Aranda-Usón et al., 2019).

CE activities are expected to create employment (Ilić and Nikolić, 2016). The MacArthur Foundation expected 1.4-2.8 million new jobs within the EU between 2012 and 2020 through CE implementation.

The perception of a company engaging in CE activities is influenced in a positive way. Customer satisfaction can be reached through innovation in service levels and by meeting sustainability expectations (De los Rios & Charnley, 2017).

First-Mover Strategy

A first-mover advantage is most commonly referred to as a company being the first to execute a specific business strategy – anything from product or technological innovation to new marketing and sales techniques (Lowe and Atkins, 1994). Consequently, pioneering companies are able to gain economic benefit by "being first" (Lieberman and Montgomery, 1988). In contrast, a follower or imitator is a firm with later adoption of a new product or practice (Bolton, 1993). A first- or early-mover does not refer to a single firm, but to a strategy of pioneering in a new segment or industry. Similarly, (fast-) followers do not refer to one specific second firm, but to the strategy of reacting to competitor moves regarding their innovation strategies.

In early research, three major advantages and disadvantages of being a first-mover were discovered (Gilbert and Birnbaum-More, 1996; Lieberman and Montgomery, 1988). Technological advancement, market pre-emption and establishment of switching costs for consumers were early-identified factors that benefit first-movers.

Technological leadership advantages are gained through rapid cost reduction (Golder and Tellis, 1993), which is achieved by quickly advancing along the experience and learning curve (Lieberman, 1987). A first-mover strategy is increasingly beneficial if the business is dependent on scale and the company is fast to invest in capacity expansion (Kerin et al., 1992). The potentially large capacity investment further forms an entry barrier for followers who may be unwilling to invest in the large upfront cost. Successful execution of patents can further benefit a company through a temporary monopoly position (Mansfield, 1986), which allows first-movers to benefit from innovation through their protected intellectual property (IP). However, IP patents have rarely been found to successfully protect against imitation (Mansfield, 1985).

A first-mover can achieve market pre-emption by controlling important assets such as skilled labor, sales and distribution channels, manufacturing plants or other important input factors. One firm alone can rarely pre-empt all assets alone, giving several early-movers an advantageous position over late-movers (Lieberman and Montgomery, 1988).

Switching costs can be actively established through binding contracts with customers and are naturally built as customers get used to the first-mover's product and are convinced of its quality. Industry pioneers can achieve early brand loyalty and establish their product as a representative for a whole category, e.g. Kleenex or Kärcher (Carpenter and Nakamoto, 1994). Followers require higher marketing investment and skills to attract customers that have already fulfilled their need with the existing first-mover offer (Lieberman and Montgomery, 1988). Uncertainty among customers usually does not justify the active search and switch to a later-entered product (Lowe and Atkins, 1994). The reputational benefit of first-movers is especially strong in the service industry. It is important to note that none of the three advantages are exclusive to one company, rather more than one early-mover can benefit from them.

On top of the three initial major advantages, Akhigbe (2002) stated the additional advantage of shareholder signaling. The announcement and production of new products improved the standing of the firm as an innovative pioneer, therefore creating shareholder value and improving the firm's access to capital.

A downside for first-movers is that they may unintentionally build up infrastructure or other assets for followers to free-ride on. There are also general risks of untested market uncertainty and the risk of technological developments potentially making early investments outdated (Lieberman and Montgomery, 1988).

Followers can free-ride on first-mover investment, particularly if IPs are not well protected. Products or offerings can be copied, and followers can gain from fast learning based on the first-mover's experience curve improvement (Lieberman, 1987). Ironically, the greater the first-mover's advantage of moving along the learning and experience curve, the greater the advantage for followers to observe and copy the first-mover's knowledge. It may be logical to leave the costs and efforts of R&D, infrastructure establishment and buyer education to the first-mover if followers can benefit from these investments (Guasch and Weiss, 1980).

Technological developments and customer needs may change after the first product is introduced. First-movers are often blind to this changing environment since they are too focused on their product and technology and suffer from “incumbent inertia” – which binds the pioneer to sunk costs and unwillingness to cannibalize existing offers or changing overall strategies, therefore hindering innovation within first-mover firms (Sofka and Schmidt, 2004; Fudenberg and Tirole, 1984).

Another advantage for followers is “leapfrogging” (Fudenberg et al., 1983), in which they can catch up to early-movers very fast through knowledge and new technology mentioned previously, while the early-movers are slowed down by product development, market and regulatory uncertainty and upfront cost burdens. The greater the knowledge spillover to rivals, the less attractive the first move becomes (Mellahi and Johnson, 2000). If the imitation of products and practices is easy and mistakes and successes are easily observable, learning curve effects no longer form an entry barrier for followers (Lowe and Atkins, 1994).

Wunker (2012) argues that early-movers only really benefit from risk taking under four conditions. If less than two of these are achieved, followers will overtake by learning from mistakes and potentially free-riding on existing assets.

1. Establishing barriers to entry:
    - Becoming a representative of the category the firm pioneers. Therefore, being consumers’ first association when thinking of the product or category.
    - Co-developing and refining the product while educating customers. Therefore, creating and converging consumer preferences to the product by helping to define their wants.
    - (Fully) Utilizing and therefore blocking distribution channels and/or physical infrastructure.
    - Creating a broad product portfolio that leaves no room for followers to enter a niche category. Similarly, establishing a broad range of user categories to create a network targeting multiple segments, e.g. student versus family versus business customers.
    - Building and leveraging economies of scale to outperform followers in cost and price early on.
    - Owning IP and ensuring its protection through legal measures.

2. Becoming an acquisition target:
    - Developing capabilities and assets that can only be caught with long-term time investment, e.g. protected R&D innovation.
    - Creating a sought-after brand with strong customer relations.
    - Increasing switching costs for consumers.
3. Avoiding lock-in to a specific technology or business model:
    - Developing the ability to pilot test the business, not only before deciding on final strategy, but also for adapting to different markets.
    - Succeeding in adapting technology and business model with low time and money investment needed.
    - Adapting to quickly changing customer preferences.
    - Overarching capability of rapid decision making is crucial to avoid the lock-in.
4. Avoiding high initial investment:
    - Testing the venture at low cost.
    - Choosing a business model in which costs increase more or less with income potential.

Most fast-followers are too slow to capture a significant market. Timelines for decision-making, product development and sales often delay a market entry beyond what is considered a fast-follower (Wunker, 2012). Nevertheless, followers can win when they have existing local market dominance in another field and copy winning strategies from other territories; they have a superior sales network to quickly surpass first-movers; or they can benefit from financial strength if a high initial investment is required (Schnaars, 2002).

Late-followers have a chance to succeed by using one of four major strategies. For example, while Motorola and Nokia were early-movers in the mobile phone market, late entrants such as Samsung quickly took over the industry. Samsung achieved this by:

- Exploiting previous mistakes – Samsung developed aesthetic designs while incumbent firms remained more focused on functionality, resulting in old-fashioned designs.
- Leveraging new or additional channels – Samsung offered attractive deals for mobile network providers, who, in return, offered bundled deals with a cellular contract and mobile phone.

- Using existing networks and adjacent capabilities – electronics companies can leverage either internal or partnership capabilities in screens (e.g. television) or cameras to integrate these into their mobile phones.
- Redefining the category – the most prominent example being Apple introducing touch and Internet access to mobile phones, creating a whole new product and making pure mobile phone functionalities redundant (Chesbrough, 2003).

Plant Location Decision

As stated by Bhatnagar and Sohal (2005), there is a strong relationship between qualitative plant location factors and the effectiveness of supply chains. Determinants of effective plant location can be grouped into quantitative and qualitative measures. On the quantitative side, plant location optimization is mainly based on cost factors such as transport, energy and labor costs, exchange rates, customs and tariff levels or tax levels and grants. Exchange rates can be leveraged by locating plants in a region with a weaker currency. Other operating costs may include environmental legislation, for example, countries may differ in green taxes or prices for CO2 emission certificates (Williams and Kramer, 2008). Additionally, broader economic indicators can be included in the location decision of international operations, including GDP development, income levels and national debt (MacCarthy & Atthirawong, 2003). Fixed costs and initial one-off investments are usually of smaller importance for the business location decision but have a larger influence on the plant size (Dixit et al., 2019).

Several quantitative models have been developed that optimize plant location to specific variables such as construction costs, idle capacity, or inventory (Owen and Daskin, 1998). MacCormack et al. (1994) emphasize that the overreliance of location decision on quantitative factors yield poor qualitative measures of supply chain competitiveness as mentioned above. Ferdows (1997) further highlights the untapped potential that many companies may overlook when investing in foreign plants based only on cost.

Qualitative decision factors include: labor (e.g. availability, education and skill); presence of infrastructure (e.g. land, energy, transportation and communication); favorable business and political environment (e.g. business climate, availability of financial and IT services, legislative and tax policies, government stability and foreign relations); closeness to suppliers and key markets, as well as distance to competitors and local manufacturing practices (e.g.

certifications, just in time, quality management, ISO 9000) (Bhatnagar and Sohal, 2005). Based on Davis (1993), there are three sources of supply chain uncertainty – supply, demand, and process uncertainty. The plant location decision strongly impacts supply and process uncertainty, for example, poor infrastructure may hinder efficient transportation and therefore increase supply uncertainty while poor utility infrastructure may boost process uncertainty. Additionally, Porter (2000) added qualitative factors including the existence of industry clusters and related institutions, the level of innovative culture, and the size of social networks as increasing factors in the location decision.

The soft factor place image or place brand has been introduced by Clouse and Dixit (2017) in the question of location decision. It is influenced by the visual image of an area, which is often represented by unique places or buildings (e.g. Petronas Towers are the first visual images that come to mind when one imagines Kuala Lumpur); reputation and identity of a place are influenced by any environmental or social factors in the area (e.g. climate, people's temperament and character); and lastly the sense of place that refers to visitors' experience when interacting with the location.

While offshoring was a dominant strategy in manufacturing location decisions in the 1990s and 2000s (Lewin & Peeters, 2006), after the economic recession in 2009 and even more so today, heightened consumer expectations, greater need for flexibility and supply chain disruptions partly caused through weakened international relations let managers reconsider this strategy (Bergman & Ramachandran, 2010).

The shift back to home country production or manufacturing in close or neighboring countries is caused by push and pull factors. High competition for resources in offshore markets reduce availability and increase prices (Ellram, Tate, and Feitzinger, 2013). Furthermore, looking back at the location factors mentioned previously, home production often benefits from better quality, stakeholder proximity, better IP regulation, flexibility, and ease of business, among others. In addition, the perception and branding through local manufacturing, e.g. "Made in USA", "Made in EU", can be advantageous for producing firms (Tate et al., 2014). In addition, keeping production in the home country or close-by can benefit from local trade agreements such as NAFTA (Dixit et al., 2019).

In offshoring operations, a lot of working capital is tied up in sluggish ocean freight and there is an increased need for safety stock at distribution centers while coordination efforts increase through physical and cultural distance. The attractiveness of home country manufacturing increases with ever-growing wages in developing countries and labor supply shortages; increased unemployment on the home front further triggers political incentives to bring manufacturing back (Tate et al., 2014).

Moreover, company ownership can influence plant location decisions. For example, family-owned companies with centralized ownership are more likely to reduce risk by investing in safer locations and are more likely to act in their private benefit, meaning investment decisions may differ from shareholder preferences (Lien and Filatotchev, 2015).

TEACHING NOTE

Learning Objectives

This case can be used in management and strategy classes to gain theoretical insights on first-mover and follower strategies as well as plant location decisions, especially in supply chain discussions. Additionally, the case bridges management topics with topics related to green and impact business as well as basic finance in terms of business case building. Students can learn about the mega-trend of circular economy, its facets and how business models can be based on this concept. In addition, they can gain knowledge on the circumstances under which innovators can aim for a first-mover advantage and protect this position as well as the caveats of a follower strategy. Moreover, students can learn how to evaluate the geographic positioning of (manufacturing) plants, while getting a broad understanding of the automotive industry environment through the case setting.

The case analysis may be adapted to learning objectives and class setting. For example, the quantitative business case analysis could be skipped or, on the contrary, be executed in a more thorough way by including a deep sensitivity analysis including all revenue and cost streams and by adding other potential revenue sources besides materials or recycling (e.g. reselling parts, offering other logistics services, selling certified recycled material) depending on the quantitative and finance focus of the course. Upon discussing the location decision, alternative geographies and countries can be customized for the target audience, for example, analyzing alternatives within Europe, e.g. Italy versus Germany or Poland or more globally Italy versus USA or China.

Class Plan

The class discussion can be structured into three major blocks:

1. Financial analysis: business case development (30 minutes)
    a. Develop basic calculations to evaluate the profitability of TRF using the given figures.
    b. Set up a high-level P&L statement and DCF calculation.

2. Qualitative analysis: assess the favorability of the business environment for TRF and discuss strategic directions (45 minutes)
    a. Discuss the mega-trend of circular economy and its relevance for our society and economy as well as its impact on the TRF's likelihood of success.
    b. Provide insights into the academic research regarding plant location decisions and analyze advantages and disadvantages of different strategic choices using different countries or continents as alternatives.
    c. Provide insights into the academic research regarding first-mover and follower strategies and analyze respective advantages and disadvantages for strategic decisions for TRF.
3. Conclusion, and decision-making (15 minutes)
    a. Provide a profound answer to the case question by deciding whether Bauer, and therefore Dupp, should co-finance the project or not.
    b. Give a recommendation on the location decision of the factory among alternatives, and further decide whether the project should be executed as soon as possible or whether the time is yet to come.

Analysis

Business Case Development

How profitable would the business be looking at a five-year plan? What EBIT/EBITDA margins could be achieved?

(i) In order to calculate high-level profitability metrics, we will first calculate the vehicle throughput that can be achieved given the ramp-up and full capacity figures by simply multiplying the full capacity vehicle units that can be processed with the percentage figure indicating the targeted utilization in the respective year.

Quantities	Plan 2022	Plan 2023	Plan 2024	Plan 2025	TV 2026 ff.
Quantity					
Max. capacity, in vehicle units	120.000	120.000	120.000	120.000	120.000
Ramp-up, in %	0%	65%	100%	100%	100%
Volume, in vehicle units	0	78.000	120.000	120.000	120.000

(ii) Given the prices in Exhibit 11, we can multiply the total revenue achieved per vehicle by the factory volume in the respective year to get to the annual revenue figure that we are planning to achieve (481,36€ x 78.000 = 37.546.090€ for the capacity in 2023 and 481,36€ x 120.000 = 57.763.200€ for the years 2024ff when TRF is running on full capacity).

Due to the high volatility of raw material prices, it is doubtful that planned revenue per vehicle remains constant over time. However, the business models' volatility to input factors will be addressed in a later question and the calculations should be done under this basic assumption of constant prices.

Additionally, it may support the class discussion to brainstorm other potential sources of revenue that can be added to the business model.

Prices, per vehicle in EUR	Plan 2022	Plan 2023	Plan 2024	Plan 2025	TV 2026 ff.
Vehicle Materials					
Scrap steel	210	210	210	210	210
Catalyst	90	90	90	90	90
Engine	80,5	80,5	80,5	80,5	80,5
Aluminum	46,67	46,67	46,67	46,67	46,67
Other	54,19	54,19	54,19	54,19	54,19
Total	481,36	481,36	481,36	481,36	481,36
Sales of vehicle material in EUR	0	37.546.080	57.763.200	57.763.200	57.763.200

(iii) On the cost side, Exhibit 10 provides the cost breakdown per sourced vehicle (landed cost at the plant). We can multiply the total costs per vehicle by the factory volume in the respective year to get the annual cost figure that we are planning with (350,27€ x 78.000 = 27.321.060€ for the capacity in 2023 and 350,27€ x 120.000 = 42.032.400€ for the years 2024ff when TRF is running on full capacity).

Again, one can question the stable cost structure over time, which is an issue to be addressed in the sensitivity analysis.

Costs, per vehicle in EUR	Plan 2022	Plan 2023	Plan 2024	Plan 2025	TV 2026 ff.
Vehicle key cost parameter					
Vehicle sourcing	33,28	33,28	33,28	33,28	33,28
Vehicle transport	49,39	49,39	49,39	49,39	49,39
Labor for disassembly	148,86	148,86	148,86	148,86	148,86
Depreciation	40,63	40,63	40,63	40,63	40,63
Other (incl. SG&A)	78,11	78,11	78,11	78,11	78,11
Total	350,27	350,27	350,27	350,27	350,27
Costs of vehicle supply in EUR	0	27.321.060	42.032.400	42.032.400	42.032.400

(iv) Capital expenditure is the investment a firm makes to purchase, maintain, or upgrade fixed assets (e.g. buildings, vehicles or equipment). The capital expenditures given in Exhibit 12 must be budgeted correctly in the years they are incurred. Therefore, we must only allocate half of the systems, machinery, and other production equipment expenses to the first investment year (2022), since the case states that the other half of investments only happen after the plant testing phase in 2022. Moreover, one must add the estimated half a million euro of additional CapEx expected to occur annually from 2023 onwards.

2022: 12.200.000€ + 16.974.000€ x 0,5 + 2.890.000€ x 0,5 + 1.900.000€ + 650.000€ = 24.682.000€

2023: 16.974.000€ x 0,5 + 2.890.000€ x 0,5 + 500.000 = 10.423.000€

2024ff: 500.000€

CapEx level of completness	CapEx, in EUR	Plan 2022	Plan 2023	Plan 2024	Plan 2025	TV 2026 ff.
Building	12.200.000	1	1	1	1	1
Systems and machinery	16.974.000	0,5	1	1	1	1
Other production equipment	2.890.000	0,5	1	1	1	1
Internal logistics (forklifts, cranes, trucks, etc.)	1.900.000	1	1	1	1	1
Equipment for offices	650.000	1	1	1	1	1
Total	34.614.000					
	annual invest after 2022					
CapEx	500.000	24.682.000	10.432.000	500.000	500.000	500.000

(v) The lifetime of assets within capital expenditures are given in the case. In addition, it is stated that a linear depreciation method is applicable. Linear depreciation allocates the capital budgeted in equal amounts for each period for the entire life of a fixed asset. For the years 2022-2025 we can therefore divide the total CapEx per asset by the lifetime in years (e.g. for the building 12.200.000€ / 35 years = 348.571€ per year of depreciation are expected). The "terminal" depreciation value is given in the case to be used in 2026ff.

Depreciation, in EUR		Plan 2022	Plan 2023	Plan 2024	Plan 2025	TV 2026 ff.
	useful life					
Building	35	348.571	348.571	348.571	348.571	
Systems and machinery	8	1.060.875	2.121.750	2.121.750	2.121.750	
Other production equipment	8	180.625	361.250	361.250	361.250	
Internal logistics (forklifts, cranes, trucks, etc.)	6	316.667	316.667	316.667	316.667	
Equipment for offices	6	108.333	108.333	108.333	108.333	
Total		2.015.071	3.256.571	3.256.571	3.256.571	1.354.541

(vi) To retrieve expected net income before tax and interest expenses (EBIT), we deduct cost of goods sold and operating expenses from revenue. The costs listed above depict operating expenses (excluding CapEx) and should therefore all be deducted in this calculation. Since depreciation is also considered an operating expense, this cost must be added back to EBIT to retrieve the EBITDA figure.

Example 2023: The annual revenue figure of 37.546.080€ calculated in (ii) represents the baseline from which the annual costs of 27.321.060€ calculated in (iii) are deducted, equating to the EBIT value of 10.225.020€. To retrieve EBITDA, we add back the annual depreciation of 3.256.571€ calculated in (v) giving us the final EBITDA value of 13.481.591€. The respective shares/margins are calculated through a division of the respective figure by total revenue.

P&L

EUR	Plan 2022	Plan 2023	Plan 2024	Plan 2025	TV 2026 ff.
Revenue					
Sales vehicle materials	0	37.546.080	57.763.200	57.763.200	57.763.200
share of sales		*100,0%*	*100,0%*	*100,0%*	*100,0%*
Costs					
Costs vehicle provision	0	-27.321.060	-42.032.400	-42.032.400	-42.032.400
share of sales		*72,8%*	*72,8%*	*72,8%*	*72,8%*
EBIT	0	10.225.020	15.730.800	15.730.800	15.730.800
share of sales		*27,2%*	*27,2%*	*27,2%*	*27,2%*
Depr. & Amortization	2.015.071	3.256.571	3.256.571	3.256.571	1.354.541
share of sales		*8,7%*	*5,6%*	*5,6%*	*2,3%*
EBITDA	2.015.071	13.481.591	18.987.371	18.987.371	17.085.341
share of sales		*35,9%*	*32,9%*	*32,9%*	*29,6%*

The operating model of TRF under the given sales and cost estimates forms a profitable business. The calculated EBIT and EBITDA margins are significantly higher than the ones achieved by Dupp of around 7% and 9% respectively. The operation of TRF under the Dupp corporate portfolio would therefore improve average profitability. To substantiate the first positive impression of the business model, the following analysis will include the one-off capital investments and discounted cash flows to gain insights into whether the investment has a positive net present value.

How would a DCF calculation evaluate the business case using the initial assumptions from Bauer and Bellegri?

(vii) Since we already calculated EBIT, we will use this figure as a starting point to derive free cash flow. Free cash flow then reflects money generated in the respective year that is free from any obligations, internal or external. It is derived by deducting interest, taxes, Δ net working capital, capital expenditures and adding back net borrowing, depreciation and amortization. From the case input, we can assume interest and net borrowing to be zero, therefore slightly simplifying the calculation. Subtracting taxes from EBIT will equate to net operating profits less adjusted taxes (e.g. 2023: 10.225.000€ – 2.454.005€ = 7.771.015€), where taxes are the given tax rate of 24% multiplied by EBIT (e.g. 2023: 10.225.000€ x 24% = 2.454.005€).

From there, adjustments are made for depreciation and amortization, CapEx and working capital calculated in (v), (iv) and Exhibit 13 respectively.

Example 2023: 7.771.015€ + 3.256.571€ – 10.432.000€ – 982.869€ = -387.282€

Derivation of FCFF EUR	Plan 2022	Plan 2023	Plan 2024	Plan 2025	TV 2026 ff.
EBIT	0	10.225.020	15.730.800	15.730.800	15.730.800
-taxes	0	-2.454.005	-3.775.392	-3.775.392	-3.775.392
NOPLAT	0	7.771.015	11.955.408	11.955.408	11.955.408
+ depr. and amortization	2.015.071	3.256.571	3.256.571	3.256.571	1.354.541
-CapEx	-24.682.000	-10.432.000	-500.000	-500.000	-500.000
+/- change in net working capital	786.765	-982.869	6.800	23.795	165.509
Free Cashflow to the Firm	-21.880.164	-387.282	14.718.779	14.735.774	12.975.458

(viii) To discount the free cash flow back to present value, we will use the weighted average cost of capital (WACC) given in the case and discount back by the respective number of years.

Example 2023: -387.282€ / (1+0.085)^2 = -328.979€

Derivation of discounted FCFF **EUR**	**Plan** **2022**	**Plan** **2023**	**Plan** **2024**	**Plan** **2025**	**TV** **2026 ff.**
Year	1	2	3	4	5
FCFF	-21.880.164	-387.282	14.718.779	14.735.774	12.975.458
WACC	8,50%	8,50%	8,50%	8,50%	6,75%
Present value factor	0,9217	0,8495	0,7829	0,7216	10,6900
Discounted FCFF	-20.166.049	-328.979	11.523.452	10.632.956	138.707.508

(ix) In the last step, we simply add up all the discounted free cash flow values to derive the DCF figure. There is no net debt adjustment required.

Derivation of DCF value **EUR**	**Plan** **2022**	**Plan** **2023**	**Plan** **2024**	**Plan** **2025**	**TV** **2026 ff.**
Enterprise Value	140.368.888				
Net debt	0				
DCF value	140.368.888				

Since the DCF value is positive and already includes initial investment costs, the future cash flows generated by the factory are higher than the initial investment. From a financial perspective, it is advisable to invest in the business under the current assumptions. However, the case states that price fluctuations are a significant risk factor for the business. The cost and revenue estimates used may not be representative for future prices. A sensitivity analysis can provide insights into the robustness of the business case.

Sensitivity to changing costs and prices: How do the two most relevant cost and revenue factors respectively influence the expected DCF value if they should change?

(x) Since the basic business case calculation assumes constant revenue and cost structures, but the case highlights the difficulty of fluctuating material prices and old vehicle prices, it is beneficial to conduct a sensitivity analysis to investigate the profitability of the business case with changing cost and revenue factors.

From all cost sources, sourcing and transport are likely the most difficult to predict given their volatility. Labor costs in a given country can be estimated and are rather stable. Similarly, depreciation and SG&A costs can be more easily influenced by the business, thus are easier to control. Therefore, it makes sense to conduct the sensitivity analysis using the sourcing and transport cost dimensions. The matrix shows, in bold, the current expected cost levels and DCF value and indicates the change in DCF value with changing transport and sourcing costs. It is advisable to create a matrix with a rising cost structure from the base case to see at what point the venture becomes unprofitable, ceteris paribus (c.p.).

On the revenue side, scrap steel and catalyst material make up the largest portion, together over 60%. Therefore, these two revenue factors should be analyzed in a sensitivity matrix. However, a sensitivity analysis can also be performed on all revenue dimensions if one wishes to shift the focus of the case towards this investigation.

k EUR		Vehicle transport cost		
		49,4	75,0	100,0
Vehicle sourcing cost	**33,3**	**140.368,9**	110.595,2	81.532,9
	50,0	120.927,0	91.153,3	62.091,0
	75,0	91.864,7	62.091,0	33.028,7
	100,0	62.802,4	33.028,7	3.966,5
	125,0	33.740,1	3.966,5	-29.224,4
	146,2	9.135,0	-23.359,6	-61.599,5
	200,0	-66.528,2	-105.704,1	-143.943,9

k EUR		Scrap steel price		
		140,0	175,0	**210,0**
Catalyst price	30,0	-127.211,6	-35.040,9	36.444,3
	45,0	-86.793,0	-467,9	63.306,5
	60,0	-47.767,7	27.339,3	89.542,3
	75,0	-9.977,7	54.425,3	115.212,1
	90,0	18.154,3	80.862,8	**140.368,9**
	105,0	45.472,0	106.715,0	165.059,1
	120,0	72.118,2	132.037,3	189.323,8

On the cost side, one can observe that even when vehicle transport costs double, the business case would still retain its profitability (c.p.). The vehicle sourcing costs could increase by almost 400% to still land with a positive DCF (c.p.). Under the same ceteris paribus assumption, the sales value achieved per catalyst could be reduced by 2/3; or the scrap steel price could fall by 1/3 and still leave a positive net present value. The profitability is therefore quite robust towards changing cost and revenue circumstances.

Circular Economy Impact

Does the business model fit into the CE principles? Which dimension(s) does it represent?

The Recycling Factory enables the CE principle of recycling and to a certain extent, could be integrated into the principles of reuse and recover. To narrow this down, it makes sense to follow the "CE funnel". Applying it to the vehicle ecosystem implies the following: reducing the number of vehicles purchased and only replacing them when absolutely necessary. Even a switch to electric mobility, which is commonly perceived as a green alternative, is not a behavior that follows the principle of reduction since production is resource intensive. Making use of a car until its end-of-life follows the reduction principle. TRF therefore does not benefit from, nor does it enable reduction.

If a vehicle is not used to its end-of-life by the initial owner, it should be reused by another (i.e. secondary car market). If we apply the reuse principle, not only to the full product but also to its components, TRF could play a role in the execution of this CE principle. If functioning vehicle parts are extracted during the disassembly process, they could potentially be sold and therefore reused in other vehicles as spare parts or in other forms of use. However, in the base case of only selling raw material and not parts, TRF has no impact on this CE dimension.

The principle of repair would imply that broken vehicles should not be considered end-of-life, rather repaired and made fit for continued use. This principle, therefore, does not fit into TRF's process.

Remanufacturing, referring to the use of well-working parts from end-of-life products as input for new products, does not follow the TRF model since potential vehicle parts would not be used as input for new products, but rather as spare or replacement parts.

The principle of recycling is best fulfilled by TRF since it takes end-of-life vehicles and aims to extract the original resources such as steel, aluminum and more, that can be fully repurposed as the basic material for new products.

Recovery is not executed but somewhat enabled by TRF, in the sense that the broken-down materials that cannot be sold as part of the revenue stream can be used as input for the recovery process.

Is the move towards a circular economy of full benefit for the business model and the corporation, or do some aspects work against its longevity?

As mentioned in the previous question, the operations will benefit from growing interest in reuse, recycling, and recovery. The question is whether this growing interest in CE activities will actually occur. Increasing environmental pressures as demonstrated by ever-growing temperatures and increasing cases of natural disaster and extreme weather all around the world has mobilized many resources to investigate economic countermeasures. These circumstances put pressure on political leaders to incentivize sustainable business practices. It is therefore likely, that CE operations will be increasingly enforced; it can be a strategic move to gain expertise in these areas early on.

As shown in the literature review section, CE practices enable a decoupling from raw material price risk. It is important to distinguish here between the benefit for the economy as a whole and the benefit specific to Dupp. By being part of the “closed loop system” and enabling raw materials to be sourced locally through the recycling process, price volatility – at least in the long run – will decrease in the market. Dupp, as a company with the need to source metals for their own products, can benefit from this by using their own supply and can further have a positive spillover effect on other market participants. The same can be said about supply chain risk. Due to international power dynamics, this may benefit the local governments and other industry players to the same extent as Dupp benefits from the reduced risk.

Another indirect benefit may be the reduction of externalities caused by long, global supply chains. Many metals are sourced from all around the world and have a much greater CO2 footprint than recycled, local metals. Again, this is only an indirect benefit for the operating company since the benefit will only substantiate in a long-term reduction of climate impact on the economy.

A big deal for operations such as TRF is the positive effect on company perception from customers and investors alike. New forward-looking innovations can be leveraged to impress shareholders and convince investors that a company is up to speed with the latest industry trends. In addition, more and more customers have their own goals for sustainability that Dupp can leverage. For example, OEMs that partner with TRF can use the reduced carbon footprint of their cars’ lifecycle in their own marketing activities.

On the downside, not all dimensions of CE are moving in favor of TRF operations. The principle of reduction implies a shift towards lower car demand and less frequent replacement of vehicles. As a consequence, there would be less end-of-life vehicles as an input source for TRF. In addition, one should not forget about the bigger picture: since some of Dupp’s other business segments are highly dependent on the development of the car industry, the reduction of vehicle supply would greatly harm their business overall. Moreover, the reuse of cars on the secondary market and the increase repair of cars following CE principles would have a similar effect on Dupp as outlined by the consequences of reduction.

Timing decision

Which factors influence the timing decision? Is it beneficial to start operations as quickly as possible or can the company benefit by first observing competitor moves?

To crack down on the timing decision, one can first refer to the major first-mover leverage dimensions of technological advancement, market pre-emption and establishment of switching costs.

From a technological perspective, the benefit of fast advancements along the learning curve are not as significant as in high-tech industries. However, the business would benefit from technology that can be adapted from adjacent fields. Dupp's conveyor belt systems and other related final assembly systems, as well as great knowledge of automotive production processes are a great advantage in the development of superior disassembly processes. As mentioned in the case, there is little intellectual property that could protect the technological advancements over the competition. One major factor however, that would strongly benefit early market entry is scalability. Research shows that the first-mover advantage is especially significant when businesses depend on scale. TRF could benefit from an optimized cost structure from quickly scaling operations, even beyond the 120.000 vehicles per year through plant extension.

Market pre-emption is of little relevance for categories such as labor and sales channels. As mentioned before, competition for highly skilled labor is low for TRF and sales channels cannot be effectively blocked either, since the recycling process downstream is not as limited in terms of volume as, for example, supermarket space would be in other industries. Additionally, the pre-emption of physical space is not a lever to be pulled for TRF since the business model does not rely on rare urban areas or other forms of scarce land. Nevertheless, the concept of pre-emption is very important on the supply side of the business model. There are only a limited number of vehicles that will reach end-of-life each year and only a limited number of companies that can provide vehicles at large scale. This implies that a company that can pre-empt this supply and gain access to the supply streams early on will have greater advancement.

The issue with limited number of providers, such as OEMs, also ties in with the establishment of switching costs. As an early-mover, Dupp has the opportunity to partner with OEMs and sign supply contracts with them. They could potentially build an even stronger barrier to entry by achieving exclusive and long-term deals with OEMs. Dupp is in a rather advantageous position to achieve this due to their proximity to the automotive industry and the big players within. As an early-mover, the TRF brand can establish itself as the "go-to" car recycler with loyal customers and become the default when thinking about this category. This becomes even more important when considering the limited options of differentiation in this business besides cost. The quality differences in final raw material will be insignificant and unobservable. Only service levels to vehicle suppliers are a differentiating factor in attracting supplier contracts.

An additional motive for early market entry could be the signaling effect to investors that perceive the move as a positive sign of an innovative company.

On the downside, there are some significant risks to consider. The high dependency on suppliers has the underlying risk that OEMs eventually decide to operate a similar system by themselves. Especially in the long run, when the EV share among car fleets increases, OEMs will likely be more involved in the recycling process due to the high battery value. This is indicated by Källenius for the Mercedes strategy in the case.

The transition to electric mobility further increases the risk of missing the timing to adjust to new technological needs (e.g. adapting the disassembly process to new power trains and developing the required technology to break down battery materials).

OEMs as well as any other followers would be able to copy the business model very easily. This is also a threat to the previously mentioned opportunity to benefit from early scaling. Followers with deeper pockets are able to set up larger plants and immediately catch up on any cost advantages. Car manufacturers themselves and other Tier 1 suppliers and vehicle contract manufacturers (e.g. Bosch or Magna) would not lag behind Dupp's capabilities in vehicle manufacturing. The problem of easily observable and easy to copy business models negatively ties into the opportunity to build a business that is better to acquire than to develop internally. Followers would have little benefit in terms of major time savings and capability acquisition from acquiring TRF over setting up their own operations.

Location Decision Analysis

From a cost perspective, is the plant location in Northern Italy favorable for the desired operation? How does it compare to operations in other European regions?

To make the location decision criteria more tangible and comparable, it is advised not to simply look at Italy and provide a yes/no decision, but to define alternative countries to create specific comparisons. For this case analysis, Germany and Poland will be referred to as potential alternatives to Italy (alternatives may be customized based on classroom setting).

Cost factors such as exchange rates, tariff restrictions (or other trade barriers), and customs are not as relevant for the business model of TRF within the EU. These cost factors are more significant for businesses that require intercontinental operations and trade. Even though TRF is an international concept, the operations would be rather local (e.g. business in the US would be served by a separate location in the US and therefore has little interference with the aforementioned costs). However, even within the EU, favorable exchange rates can be leveraged while also benefiting from the no tariff, free trade area. The alternative location in Poland could benefit from the weaker zloty and therefore reduce costs for the parent company operating in euro.

Due to rather high labor intensity of the business, labor costs are something that should be specifically highlighted. Even within Europe, wages vary significantly. Since the disassembly process does not require university-educated workers and wage levels paid by TRF may not be competitive, minimum wage levels in respective countries can be used as a baseline for comparison. In Italy, there is no minimum wage law in place, however companies can expect to pay at least ~6-7€/hour. In Germany and Poland, minimum wages are 9.82€ and 3.81€ (converted from zloty) respectively (Lübker and Schulten, 2022). These figures highlight the significance of wage levels for high labour businesses; the cost of labour of doing business in Poland could be less than half of German costs.

For all the factory machinery, energy costs may also influence the location decision. Disregarding energy sources for decision making (some companies may want to avoid nuclear or coal power sources or require a certain level of renewably sourced energy as part of their own sustainability standards), the per kWh cost of electricity for industry customers in 2021 in euro-cent was ~12-18 in Germany, ~10-16 in Italy and ~9-11 in Poland (Statista Research Department, 2022); once again, Poland has the clear cost advantage.

The influence of taxes can be separated into corporate tax levels as well as national or regional tax incentives for investment. Corporate income taxes are 29.8% in Germany, 24% in Italy and 19% in Poland (OECD, 2022). Due to the strong political promotion of the "green economy", TRF would likely receive subsides for their initiative within the EU.

Geographic location will influence transportation costs; the closer the factory is to vehicle supply, the lower the transport costs. Strategically, it would therefore make most sense to be close to the largest car markets by unit. In Europe, these top five markets are Germany, France, UK, Italy and Spain. It is therefore beneficial to be located in central Europe. In our comparison, Italy, Germany and Poland are rather central and transportation costs would likely not be significantly different, however Germany and Italy would likely still benefit from the large national market and the proximity to France.

What other qualitative factors should be included in the location decision?

One of the most important qualitative factors for TRF is the availability of robust infrastructure. To ship 120.000 old vehicles a year to a plant will require either very good connections to major highways, train tracks or harbors. Since the vehicle input for a factory in northern Italy would come from all around (central) Europe, effective transportation is crucial to keep costs low and ensure safe supply chains. In addition, other infrastructure such as a reliable energy supply and communication are important for TRF operations. However, when looking at alternatives within Europe, these can be considered as sufficient in most countries and is something to be investigated in more detail when considering expansion to other continents.

Another factor with rather low differentiation within the comparison set of countries would be the political environment and stability. Overall, all three countries can be considered stable with solid business environments. Political factors become more relevant when conducting business in countries outside a free trade area such as the EU and especially in countries with high political influence on the economy, such as China. Nevertheless, it may be of interest to observe political trends even in countries within the EU to anticipate the political agenda in the upcoming years (e.g. a shift from a more right wing to a more left wing government can lead to changes in the business conditions of that country).

The visual image of the manufacturing location can be an important factor in the external perception of TRF. Being located in the greater Milan area triggers different associations to people than a factory location in Poland. However, this factor is less important in this case than for a producing operation where “made in” labels are more impactful in marketing.

Since operations do not require specific highly qualified workers, the workforce availability is a less dominant factor in the location decision of TRF, and local manufacturing practices are not as divergent within Europe compared to intercontinental alternatives. A similar reasoning applies to factors such as an innovative culture and competitive clusters. More high-tech firms, (e.g. Facebook, Microsoft, Tesla) may choose a location such as the Silicon Valley for the access to highly skilled and educated workers, a very innovative culture and the competitive cluster; however, this is not as relevant for TRF.

The most important factor in this case's location decision is likely the ownership structure. The idea of TRF has been initiated by the CEO of an Italian company that is owned by a German corporation. Therefore, it is much more likely that operations will start in proximity to one of these owners. The location in Italy benefits from the local familiarity with the business environment, legal regulations, the language, culture, and the geography. The geographic proximity further facilitates control over a new venture.

One-off costs such as building the facility and setting up infrastructure will also differ among the countries, however, as stated in the research section, this should not impact the location decision as much as the ongoing costs and would instead impact the decision on the size of operations.

Recommendation

Through the financial analysis, it can be concluded that the investment into TRF demonstrates a financial gain with attractive margins. Additionally, since the sensitivity analysis shows that the business case is rather robust to changing prices, it is a venture to consider.

The TRF's natural alignment with a CE cycle demonstrates a future-oriented business that fits into current political agendas and trends. This fit helps to meet tightened environmental regulations and would likely benefit from governmental or EU grants. Demonstrating the ability to establish profitable ecological business models further helps a company to meet customer expectations and improve market and investor perception. The improvement of supply chain (price) risk and the associated environmental benefits can indirectly support Dupp's own operations when using its own recycled material, but mainly has a positive spillover effect on the material market.

A crucial part of execution is a fast entry strategy. Early scaling of operations will help to improve the cost structure and support market pre-emption. By attracting long-term exclusive contracts with OEMs, TRF can pre-empt the market by "owning" the vehicle supply. Being early and scaling quickly helps to build strong customer relationships, references and builds a reputation that represents the category. Furthermore, with the trend to electric mobility within the automotive industry, fast market entry ensures the capture of the large wave of traditional vehicles being replaced.

The factory location decision under the three alternatives: Germany, Poland and Italy, gives a more divergent picture. While Poland is a very attractive from a cost perspective, the plant location in Italy prevails on the qualitative side. Local operations will give Bellegri a greater feeling of ownership and would let him operate in a familiar environment in which he has a high level of expertise. The closeness in terms of geographic distance, culture, language and administrative factors can allow for much more successful company growth than in Poland. Moreover, the proximity to the first vehicle supplier Stellantis would allow operations to be cost effective early on.

In conclusion, TRF should be built as soon as possible in Italy.

CONCLUSION

This case includes several major topics of current global affairs in one discussion. The automotive sector is undertaking the most significant transformation of the past century with the shift to an EV-first strategy. At the same time, all major automotive OEMs, chemical players such as BASF, and new market entrants such as Redwood, are investing in EV battery recycling. Besides car industry trends, the constant degradation of the global environmental puts pressure on all industries to present sustainable solutions; growing hostility around the globe (e.g. conflicts in Ukraine, Taiwan, or Afghanistan) cumulate the need for industries and governments to address resource supply security. These circumstances influence the management decision of an investment in the recycling business.

The most burdensome aspect of the thesis was to evaluate how realistic and accurate cost and revenue estimates were, in addition to prioritizing managerial aspects of the case. A deep dive into how well TRF would fit into Dupp's overall corporate portfolio considering strong industry dependencies would be an interesting aspect to consider. Additionally, comparing the business model to existing car recycling plants, adding additional potential revenue streams, and including all cost and revenue variables into the financial analysis to have a multivariate variance analysis could benefit the decision-making process. Furthermore, the long-term analysis of battery recycling operations of TRF with more competitors is important to conduct when thinking about future diminishing ICE units.

It will be exciting to observe the decisions to be taken on this investment in real life and if these follow the main findings from literature by entering the market early and establishing entry barriers through switching costs and market pre-emption, and whether the qualitative influences prevail in the location decision towards a plant in Italy.

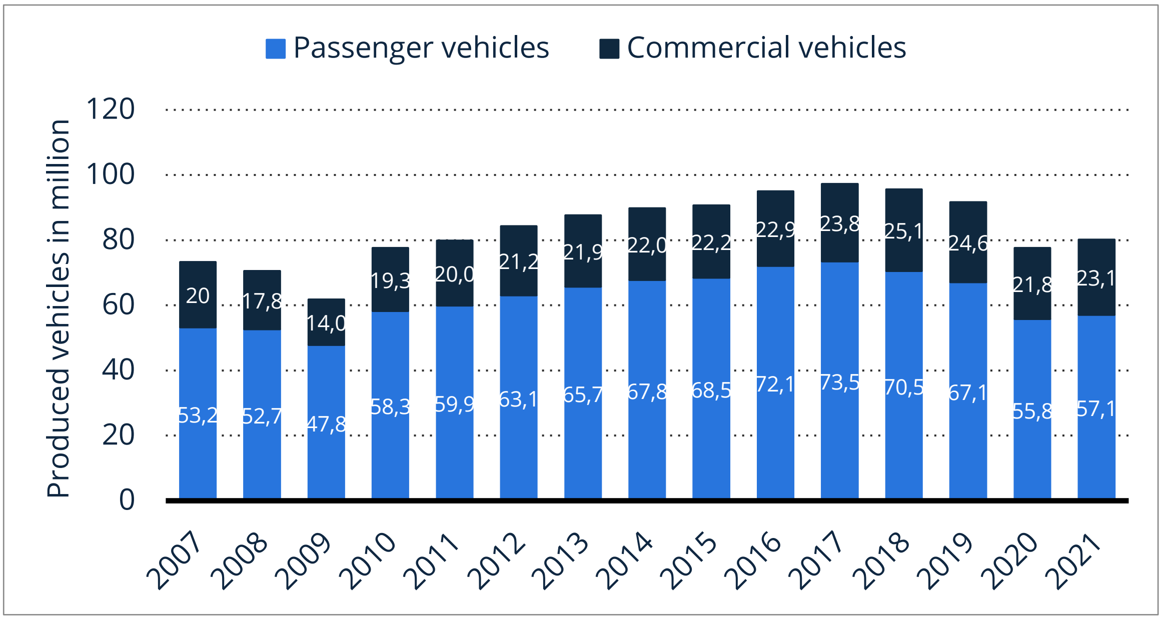
EXHIBITS

Exhibit 1: Sales by Region

In Millions of EUR except Per Share 12 Months Ending	FY 2016 12/31/2016		FY 2017 12/31/2017		FY 2018 12/31/2018		FY 2019 12/31/2019		FY 2020 12/31/2020	
Revenue	**3.573,6**	**100,0%**	**3.713,2**	**100,0%**	**3.869,8**	**100,0%**	**3.921,5**	**100,0%**	**3.324,8**	**100,0%**
Americas	—		—		—		1.053,9	26,9%	914,2	27,5%
North & Central America	770,8	21,6%	926,8	25,0%	826,1	21,3%	969,0	24,7%	852,8	25,6%
South America	79,4	2,2%	78,6	2,1%	86,3	2,2%	84,9	2,2%	61,4	1,8%
Other European Countries	1.010,9	28,3%	1.090,0	29,4%	1.184,4	30,6%	1.074,0	27,4%	760,8	22,9%
China	—		—		—		726,3	18,5%	695,5	20,9%
Germany	542,8	15,2%	485,9	13,1%	609,4	15,7%	668,7	17,1%	562,6	16,9%
Other Asian Countries,Africa,Australia	—		—		—		398,7	10,2%	391,7	11,8%
Asia/ Africa/ Australia	1.169,7	32,7%	1.131,9	30,5%	1.163,6	30,1%	—		—	

Source: Bloomberg

Exhibit 2: Global car production volume

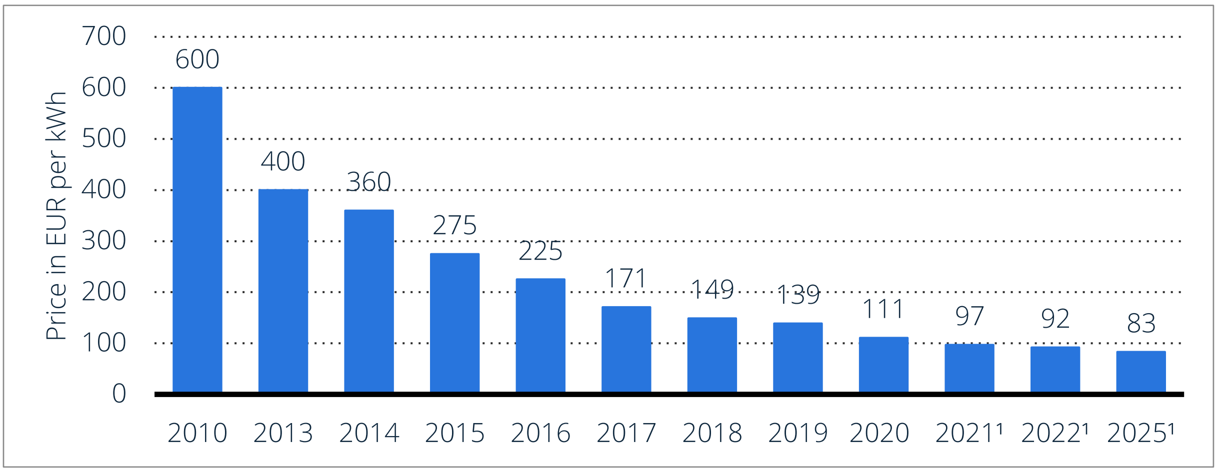


Source: Weitemeyer, 2022

Exhibit 3: Examples of tax incentives in 2019/2020

Country	Incentive	Amount	Scope
China	Exemption from vehicle tax until 2022	Complete vehicle tax	Newly bought PEVs, PHEVs, Fuel-Cell
France	Grant	Up to 10,000 €	Switch from Diesel to PEVs
	Grant	6,300 €	Purchase of new PHEVs
Germany	Subsidy	3,000 €	Purchase of PHEVs
	Subsidy	4,000 €	Purchase of PEVs
	Exemption from annual circulation tax	Based on CO2 emissions	For ten years
Japan	Exemption from car acquisition and tonnage tax	Complete acquisition and tonnage tax	For new EV owners
	Subsidy	USD 7,700	For new EV purchases
Russia	Tax free imports	Import Tax -25% ; VAT -20%	PEVs only
U.S.	Federal Government tax credits	Up to 7,500 USD	Purchase of PEVs
	Subsidies	1,500 – 6,000 USD (varies by state)	Purchase of PEVs
UK	Subsidies	Up to 3,500 BP	Purchase of EVs
Netherlands	Exemption from purchase and motor vehicle taxes until 2025	Total purchase and motor vehicle taxes	
	Subsidy	4,000 €	Purchase of new BEVs
EU	Heavy investments into infrastructure, R&D and industry. Eg. Subsidy for Tesla in Brandburg and Varta battery development (together with German government)		

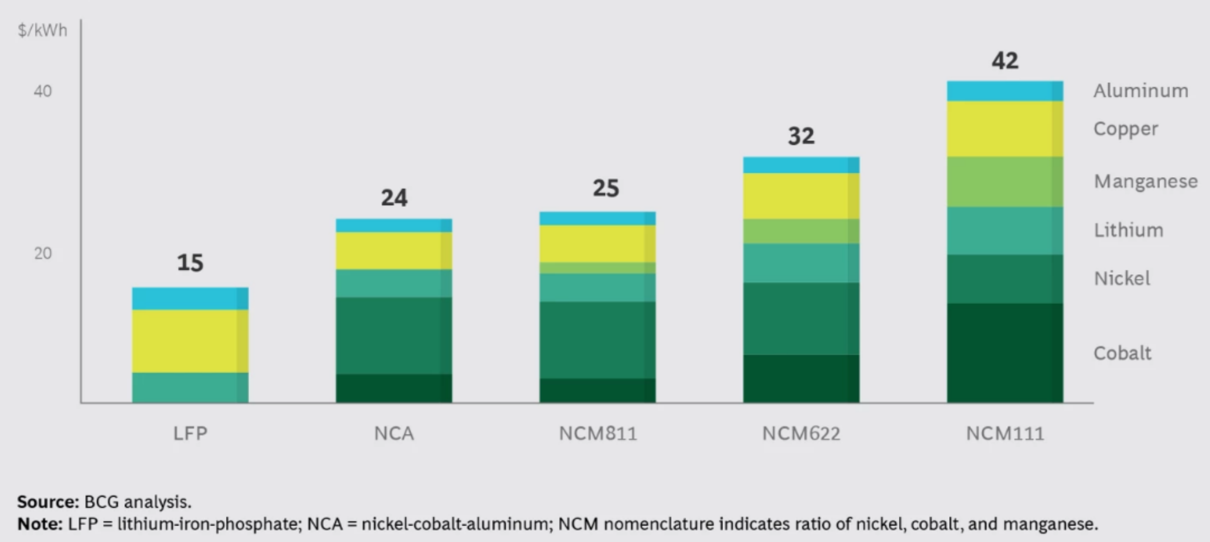
Exhibit 4: Lithium battery price per kWh



[1] *forecasted value*

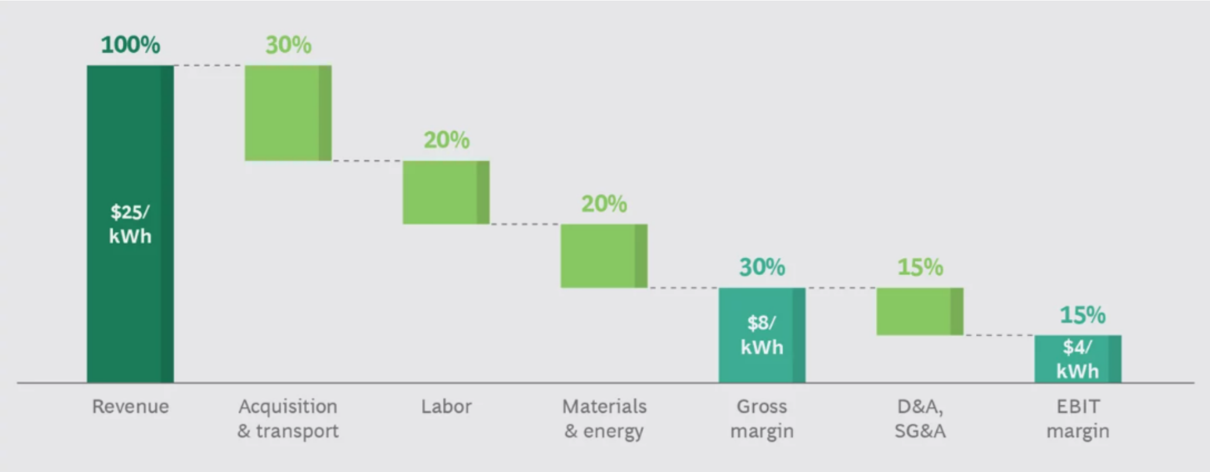
Source*:* Horváth, 2020; Bloomberg NEF

Exhibit 5: Salvage value by battery type, 2020



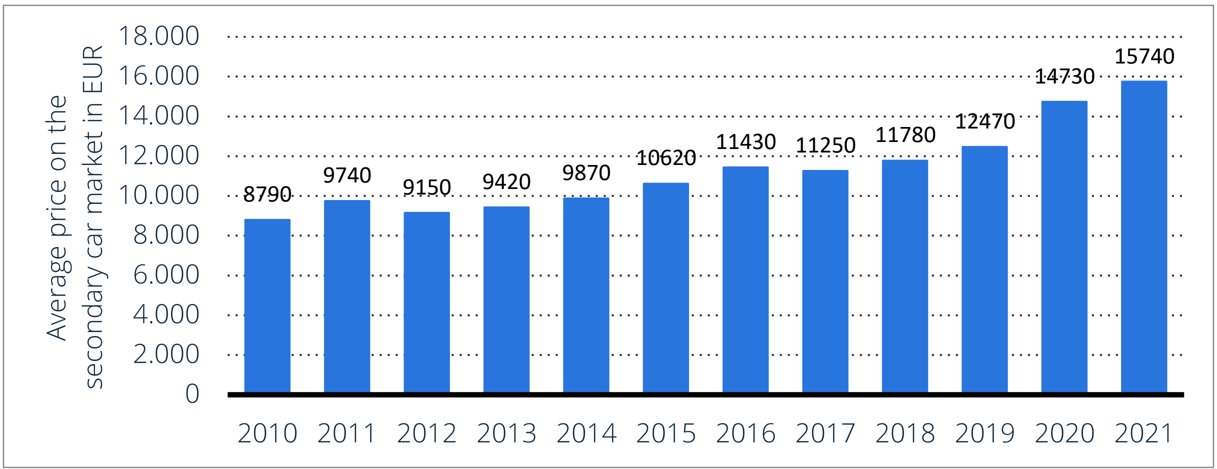
Source: Niese et al., 2021

Exhibit 6: Economics of large-scale recycler of NCM622 in China, 2020



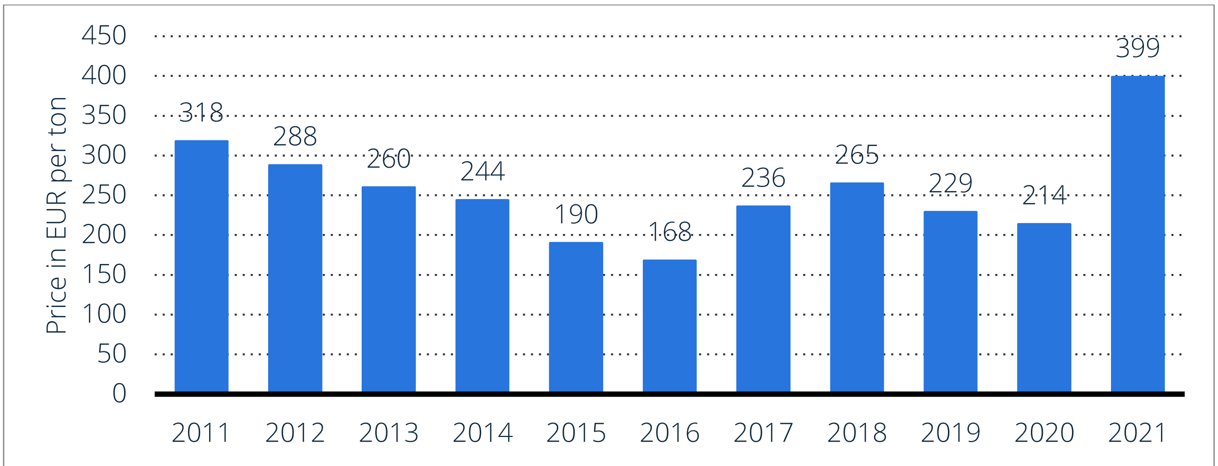
Source: Niese et al., 2021

Exhibit 7: Average prices for used vehicles in Germany



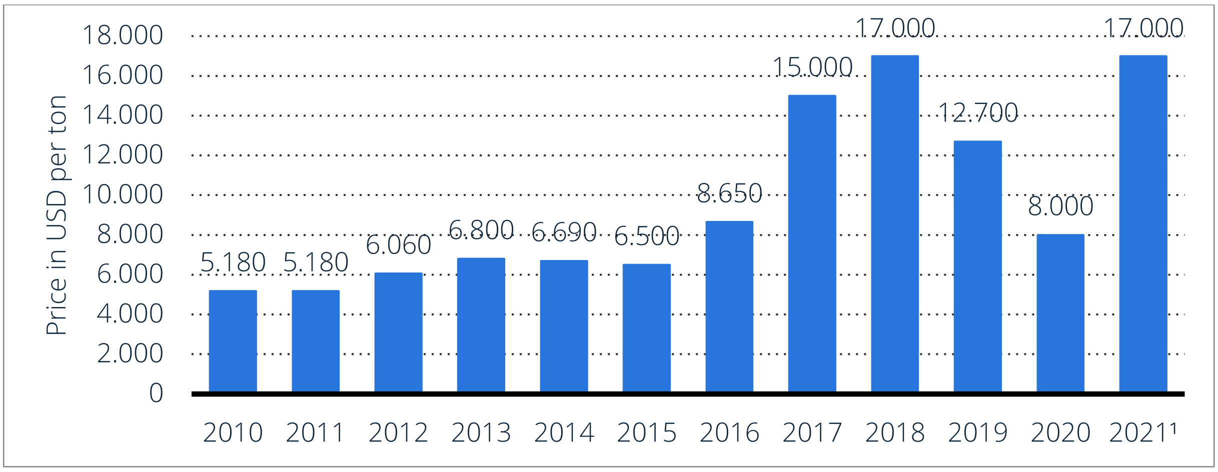
Source: Kords, 2022

Exhibit 8: Scrap steel prices in Germany



Source: Statista Research Department, 2022

Exhibit 9: Average global lithium price



[1] *Forecasted value*

Source: U.S. Geological Survey, 2022

Exhibit 10: Cost structure of TRF business case

Costs	**in EUR**
Vehicle sourcing	33,28
Vehicle transport	49,39
Labor for disassembly	148,86
Depreciation	40,63
Other (incl. SG&A)	78,11
Total	**350,27**

Exhibit 11: Revenue structure of TRF business case

Revenue	in EUR
Scrap steel	210
Catalyst	90
Engine	80,5
Aluminum	46,67
Other	54,19
Total	**481,36**

Exhibit 12: Capital expenditures of TRF

CapEx	CapEx, in EUR
Building	12.200.000
Systems and machinery	16.974.000
Other production equipment	2.890.000
Internal logistics (forklifts, cranes, trucks, etc.)	1.900.000
Equipment for offices	650.000
Total	34.614.000

Exhibit 13: Working Capital for TRF, in EUR

Working Capital	Plan 2022	Plan 2023	Plan 2024	Plan 2025	TV 2026 ff.
Trade receivables	0	4.813.567	4.813.567	4.813.567	
Imventories	0	0	0	0	
Trade payables	786.765	4.617.463	4.624.263	4.648.058	
Working Capital	-786.765	196.104	189.304	165.509	
Change in working capital	786.765	-982.869	6.800	23.795	165.509

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