

Scope 3 Emissions Assessment and Circular Economy Protocol Development at Ford Motor Company

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Abstract

Value chain (or Scope 3) emissions, stemming external to an organization's direct operations, account for over 90% of the greenhouse gas inventory of an automotive manufacturer, and are dominated by Use of Sold Products. Although Ford Motor Company (Ford) had previously reported estimates of select Scope 3 emissions categories to the CDP survey, they sought increased comprehensiveness. Through benchmarking industry leaders, we provided Ford with recommendations to enable a more complete, accurate, and transparent accounting of these emissions. Subsequently, in their 2018 CDP response, Ford estimated an additional 65 million mt CO₂e (43%) relative to the previous year's submission. Scope 3 emissions can be managed through circular economy strategies, which are a means to reduce non-renewable materials and energy, promote renewable feedstocks and energy, and create closed-loop flows across the life cycle of a product. We developed a schematic representing Ford's circular economy strategies based on the Ellen MacArthur Foundation's framework, coupled with closed-loop vehicle life cycle design. While this framework has been applied to other products, we present its first comprehensive application in the mobility sector. This schematic provides a practical format for characterizing and summarizing Ford's sustainability programs and initiatives and allows them to develop more robust sustainability strategies. Continuing to refine their emissions inventory and promoting circular economy programs are pathways for Ford to advance their position as an industry leader in environmental sustainability.

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Executive Summary

Project Significance

Life cycle greenhouse gas (GHG) emissions from vehicles make the transportation sector the largest contributor to climate change impacts in the United States. Scope 3 (indirect/value chain) emissions are particularly important, since they account for over 90% of the GHG inventory of an automotive original equipment manufacturer (OEM). Specifically, this category of emissions includes those originating upstream and downstream of an organization's direct operations. Consequently, Scope 3 emissions also provide the greatest opportunities for a company to reduce its GHG footprint.

Ford Motor Company (Ford), a large global automotive OEM based in the United States, reports all of their identified GHG emissions (Scopes 1, 2, and 3) to the CDP (formerly the Carbon Disclosure Project), a non-profit organization that seeks to collect data on the environmental impact of corporations for the sake of better management of emissions and transparency to the public. Although Ford had previously calculated emissions for select Scope 3 categories for the CDP, their GHG inventory was not comprehensive. Ford sought to improve their accuracy, coverage, and transparency in reporting Scope 3 emissions to the CDP, starting in 2018, by adopting best practices from leaders in this area. In addition to more holistic reporting, Ford seeks reductions in its environmental impact through a mitigation of Scope 3 emissions. Circular economy strategies can help reduce Scope 3 emissions, since they are targeted to reduce environmental impacts from each stage of a product's life cycle. To that end, we provided Ford with the guidance needed to both measure and manage GHG emissions, across the two interrelated phases of our project. Through a more complete evaluation of emissions in the Scope 3 phase, and an integrated representation of Ford's sustainability programs and initiatives in the

Circular Economy phase, we enabled Ford to better assess value-chain GHG emissions and develop product life cycle management strategies.

Scope 3 Emissions Assessment

The first phase was initiated by benchmarking 12 companies, both intra and cross-sectoral, for their Scope 3 CDP reporting practices and methodologies, environmental targets, and value chain stakeholder engagement. Ford's relative performance was compared, and trends/best-practices were identified by developing benchmarking assessment criteria. For instance, we compared automotive OEMs based on their Scope 3 emissions normalized per unit sold. Ford's cumulative normalized Scope 3 emissions were the lowest among all the autos benchmarked, however this was attributed to both a partially complete emissions inventory, and higher sales, relative to some other companies. Subsequently, recommendations were provided for enabling a more complete, accurate, and transparent mapping of value chain GHG emissions. Several recommendations for including additional information into the annual CDP survey were implemented beginning 2018, and are shown in **Table ES-1**. Ford estimated an additional 65 million mt CO₂e (43%) in 2018 CDP relative to their previous submission (**Figure ES-1**).

Finally, Ford also defined a threshold for determining category 'relevance', as defined by the CDP questionnaire, wherein only those categories whose computed Scope 3 emissions exceeded 5% of the total inventory were deemed to be 'relevant'. Subsequently, the only two 'relevant' standalone categories were Use of Sold Products (76%), and Purchased Goods and Services (20%). Regardless, Ford should continue tracking and managing categories labelled 'not relevant', since their cumulative GHG footprint may be significant.

Table ES-1: Select recommendations with associated change in CDP-reported GHG emissions

Proposed Recommendations	Change in Emissions (2017 to 2018, mt CO₂e)
Use of hybrid LCA to calculate emissions from Purchased Goods and Services	29,045,000
Report emissions from US medium-heavy duty trucks in the Use of Sold Products category	28,300,000
Report Franchise related emissions	1,958,000
Report emissions from End-of-Life Treatment of Sold Products	1,400,000
Report Fuel- and Energy-Related Activities emissions	1,100,000
Use of hybrid LCA to calculate Capital Goods	1,046,000
Use of alternative software for determining emissions from Waste Generated in Operations	106,000
Eliminate overlap emissions between Employee Commuting and Use of Sold Products	-547,000

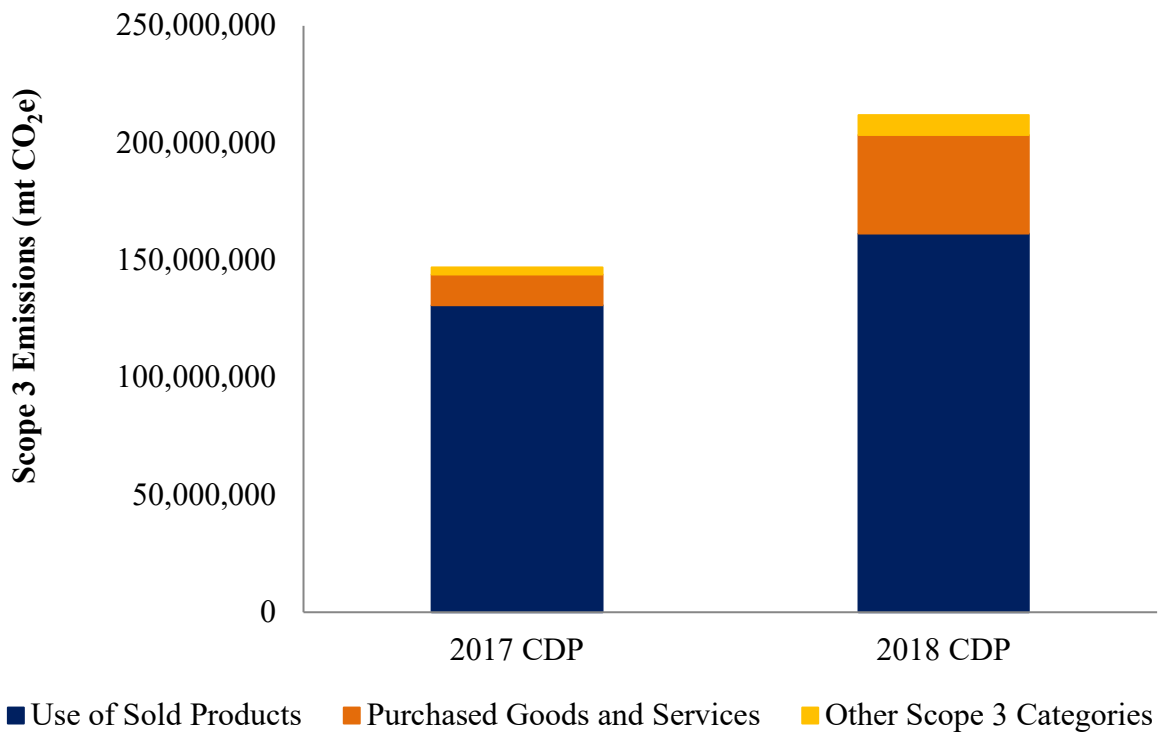


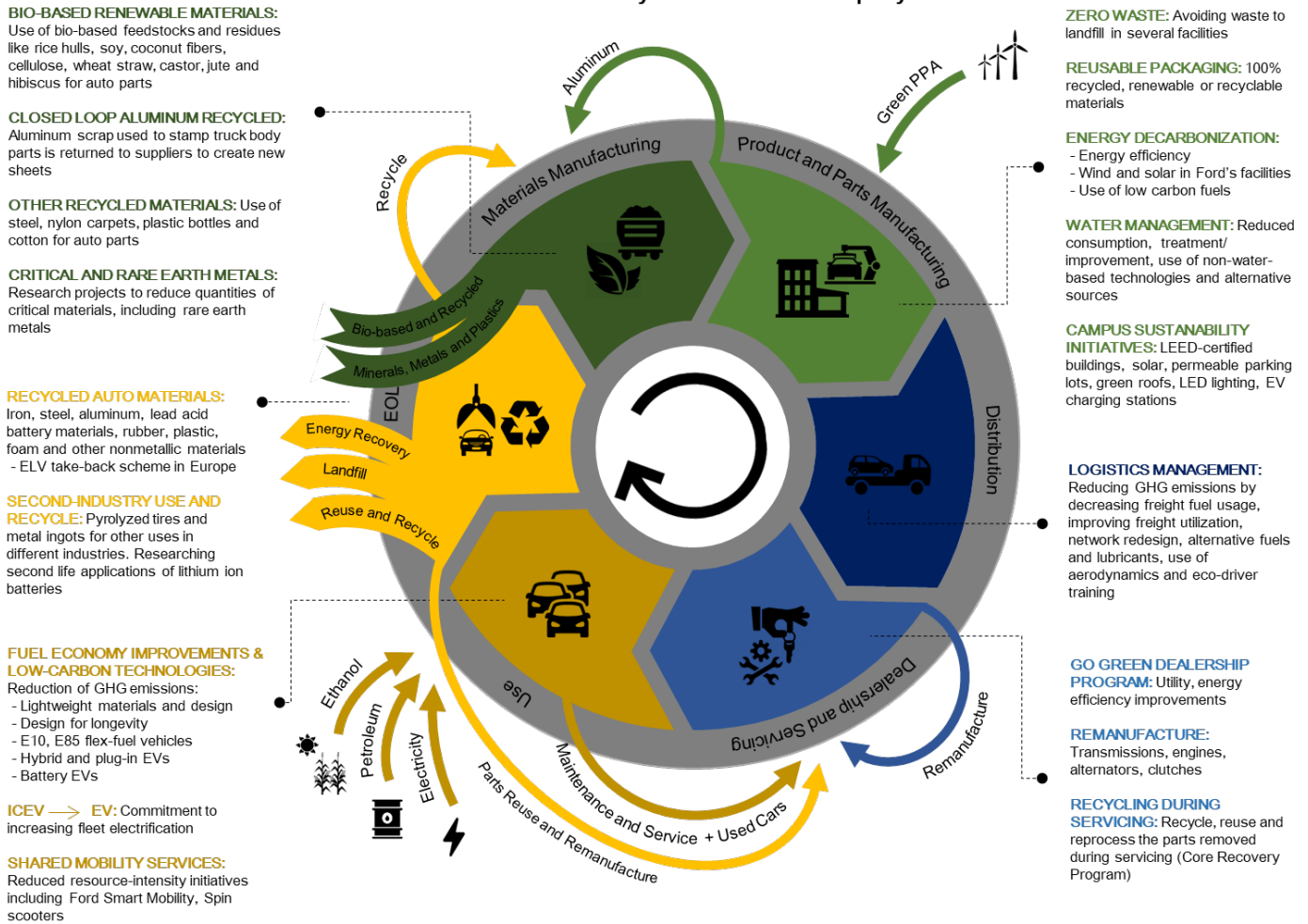
Figure ES-1: Change in reported Scope 3 emissions

Circular Economy at Ford Motor Company

Circular economy strategies are a means of reducing non-renewable materials and energy, promoting renewable feedstocks and energy, and creating closed-loop flows across the life cycle of a product, which can also decrease associated GHG emissions. We developed a schematic representing Ford's circular economy strategies, shown in **Figure ES-2**, for the company to subsequently reduce Scope 3 emissions. The company had already implemented many circular economy initiatives throughout the various stages of a vehicle's life cycle, which we highlighted based on the Ellen MacArthur Foundation's circular economy framework. While the circular economy framework has been applied to other products, this study represents its first comprehensive application in the mobility sector.

The diagram is the first comprehensive depiction in the industry of how a circular economy framework can be applied to an automotive OEM. It shows how an automobile manufacturer's sustainability goals and strategies fit into the circular economy paradigm. Further, this diagram provides a practical format for characterizing and summarizing Ford's sustainability programs and initiatives. These programs and initiatives, which are managed by different departments, are now displayed in a single schematic. This consolidated information can also be communicated more concisely to Ford's consumers and other external stakeholders. Finally, a representation of Ford's circularity efforts allows them to better identify gaps in, and improve on their sustainability strategies.

Circular Economy at Ford Motor Company



Source: Laura Aguilar Esteve, Akshat Kasiwal, Michael Kinzler. Center for Sustainable Systems, University of Michigan (2019).

EOL: End of Life; ICEV: Internal Combustion Engine Vehicle; EV: Electric Vehicle; ELV: End of Life Vehicles; GHG: Greenhouse Gases

Figure ES-2: Circular Economy at Ford Motor Company

Conclusions

We helped Ford advance its efforts to prioritize and manage Scope 3 emissions. Ford should focus most on emissions from Use of Sold Products, given that it accounts for about three-quarters of all 2018 Scope 3 emissions. To that end, continuing to refine their mapping, implementing absolute reduction targets, setting measurable goals for associated sustainability programs and initiatives, and promoting circular economy programs, are some pathways for Ford to position itself as an industry leader in both the measurement and management of value chain emissions.

1. Introduction

The transportation sector is responsible for 28% of GHG emissions in the United States and 14% of GHG emissions globally (US EPA, 2016; IPCC, 2014). With projected rising temperatures over the next century, it is important to find ways to reduce GHG emissions across the sector to reduce the negative impacts of climate change. Although automobiles are becoming more fuel efficient and low-carbon alternative fuel vehicles (AFVs) are increasing in market penetration, additional mitigation measures will have to be undertaken over the course of the coming decades to have meaningful emissions reductions (US DOE, 2018). Consequently, automotive OEMs will need to make a larger commitment to climate change mitigation by offering low-carbon mobility solutions and reducing environmental impacts across their value chains.

Many corporations are making efforts to mitigate climate change through sustainability stewardship and corporate social responsibility (CSR) measures. Environmentally conscious companies are often seen as more attractive to consumers (Branco & Rodrigues, 2006). Additionally, becoming more resource-efficient has significant economic benefits (Branco & Rodrigues, 2006). Finally, efforts to mitigate climate change will help reduce risk and limit the disruptiveness from sea-level rise, increased global temperatures, and more-frequent extreme weather-events (Allen & Craig, 2016). Despite the United States backing out of the Paris Climate Agreement, many international companies, including Ford, have reaffirmed their commitment towards meeting these global goals of climate change mitigation (Luscombe, 2017).

Ford is the 6th largest automobile manufacturer in the world (Focus2Move, 2018). Their large global presence, their vehicles, value chain, and manufacturing operations cumulatively produce annual emissions over 216 million mt CO₂e (CDP, 2018). Ford is committed to reducing its environmental impact, for which the company has undertaken numerous sustainability

programs and initiatives (Ford Motor Company, 2018). Ford is hoping to further reduce its emissions through better understanding their Scope 3 (indirect) emissions inventory, and by implementing robust circular economy strategies. The focus of this project was to propose recommendations for a more comprehensive estimation of Scope 3 GHG emissions and to provide a framework for integrating sustainability programs and initiatives into a circular economy paradigm.

1.1 Scope 3 Emissions

The *Greenhouse Gas Protocol* was jointly formed by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI) in an effort to guide policies and business strategies in carbon emissions reduction as a means of climate change mitigation (GHG Protocol, 2018). As per the *GHG Protocol Corporate Standard*, emissions are classified into three different ‘Scopes’ (World Resources Institute, 2011). Scope 1 refers to the direct emissions from owned or controlled sources within a company (World Resources Institute, 2011). Scope 2 emissions are those from purchased electricity by the company (World Resources Institute, 2011). Scope 3 refers to all other indirect emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity (World Resources Institute, 2011). Although Scope 3 reporting is not a requirement of the *GHG Protocol Corporate Standard*, it is necessary to consider these indirect emissions to get a holistic evaluation of a company’s emissions across their entire value chain (World Resources Institute, 2011). Scope 3 emissions are particularly important because they are often the largest source of the GHG footprint of a company (World Resources Institute,

2011). Consequently, Scope 3 emissions also provide the most significant opportunities to reduce emissions for a company (World Resources Institute, 2011).

Ford is committed to social and environmental sustainability and considers reducing climate impact a key responsibility and a strategic priority. To inform this strategy, the company needs a complete inventory of their GHG emissions to better understand where reductions can be made. Ford has made substantial efforts to measure and reduce their Scope 1 and Scope 2 emissions, and is now concentrating more heavily on their analysis of Scope 3 emissions. Ford reports all of their identified emissions to the CDP, a non-profit organization that seeks to collect data on the environmental impact of corporations for the sake of better management of emissions and transparency to the public (CDP, 2018). Companies disclose data and information from the year leading up to the publication of their CDP report; for example, the 2018 CDP report contains information pertinent to 2017. Previous submissions to CDP included initial estimates for Scope 3 emissions with Ford only reporting calculated emissions in select categories. Valid explanations were provided for all categories where emissions values were not reported. Ford is seeking to make improvements in the accuracy, coverage, and transparency of their Scope 3 emissions reporting by considering best-practices from leaders in this field. Beyond more comprehensive emissions reporting, Ford also expects to reduce its environmental impact by working to reduce key Scope 3 emissions.

1.2 Scope 3 Emissions Reporting

The guiding model that enables GHG inventory building and reporting is the Corporate Value Chain (Scope 3) Accounting & Reporting Standard, often referred to as the *Scope 3 Standard*, proposed by the Greenhouse Gas Protocol Organization (World Resources Institute, 2011). This

framework is a robust means for computing, accounting, reporting, and managing emissions, with applications extending to both product-portfolios and process value chains. Presently, it remains the sole globally-accepted standard for corporations to account for their indirect emissions.

According to these guidelines, Scope 3 emissions encompass those emissions which “originate from sources owned or controlled by miscellaneous entities in the value chain” (World Resources Institute, 2011). These entities are included in the reporting firm’s organizational boundary. Scope 3 emissions are categorized into upstream and downstream sources, relative to the reporting entity’s position in the value chain (**Figure 1**). Upstream Scope 3 emissions include those from employee commuting, logistics, goods procurement, and business travel, amongst others. Some downstream Scope 3 emissions categories include processing and use of sold products, franchises, and investments (see **Appendix A** for an overview of each category).

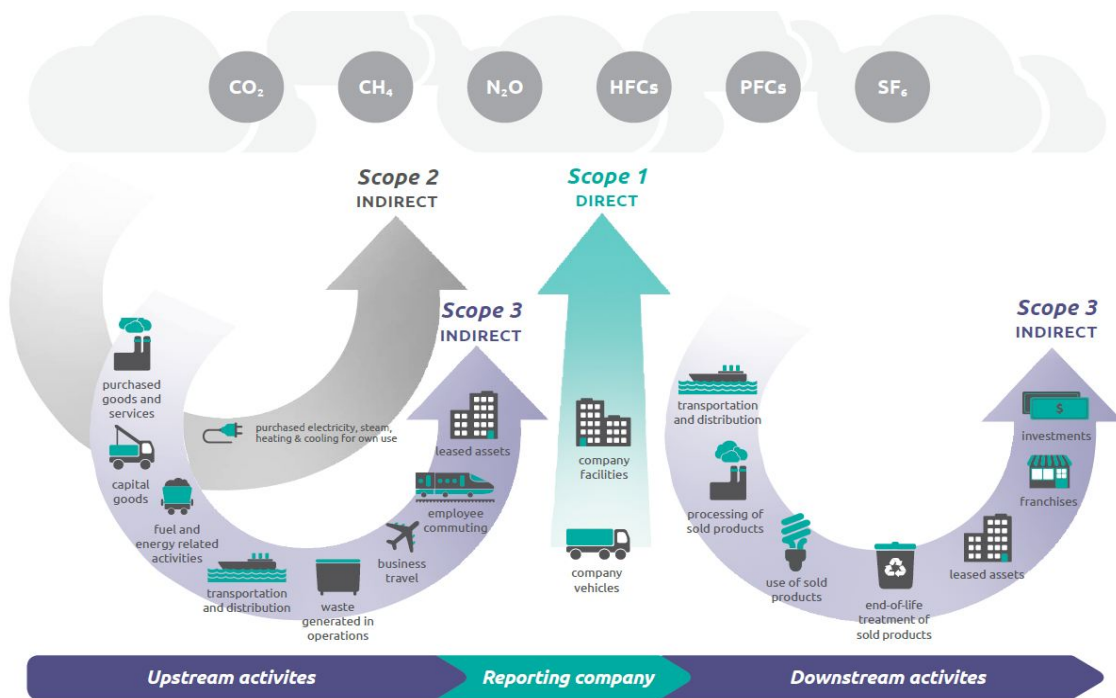


Figure 1: Conceptual model of Scope 1, 2 and 3 emissions (Greenhouse Gas Protocol, 2011)

A supplemental document including the methods for calculating Scope 3 emissions is also provided by the *GHG Protocol Corporate Standard*, which highlights relevant details regarding the associated aspects of this assessment. One crucial element involves defining boundaries for assessment, and determining the general ‘relevance’ of a particular Scope 3 category. Organizations can make this discretion based on the extent of either operational or financial control they exert, pertinent to activities under that specific category. Furthermore, reporting organizations must decide on how they source this data. Data may be industry averages, supplier-provisions, life cycle and input-output factors, or in fewer cases primarily-sourced. Inherent trade-offs between data-characteristics of time/cost of gathering, quality, representativeness/completeness, variability and uncertainty need to be acknowledged.

1.3 Circular Economy

The Ellen MacArthur Foundation, pioneers of the circularity paradigm, defines this as a nontraditional, nonlinear economy of material, energy, and monetary flows, which is regenerative and restorative by design (**Figure 2**). A circular economy/system aims to always maintain all its components, elements and products at their highest utility and value (Ellen MacArthur Foundation, 2013). Such a model enables moving away from the traditional linear economy, which is fundamentally open-ended, and resource-intensive. The underlying risks of maintaining status-quo with cradle-to-grave systems are realized through depleting finite natural reserves, price volatility in commodities, and external stakeholder pressure to transition to more sustainable practices. Further, the circular economy paradigm proposed by the Ellen MacArthur Foundation is an effective way to make the concepts of material and energy flows in industrial ecology more approachable to incorporate into business strategies.

Ford has a legacy of pursuing sustainability initiatives ever since Henry Ford incorporated biomaterials into vehicles in the 1940s (Mielewski, 2017). Ford is looking to further develop and integrate existing sustainability programs and initiatives into a circular economy framework. A circular economy is particularly important in the automotive industry due to the high resource intensity of vehicle production and use. Ford aims to reduce their resource consumption, while simultaneously reducing the amount of waste generated across the automotive value chain. Implementing a circular economy paradigm is a means for Ford to reduce Scope 3 emissions. For instance, returning scrap aluminum to suppliers can help avoid upstream emissions from producing additional virgin aluminum.

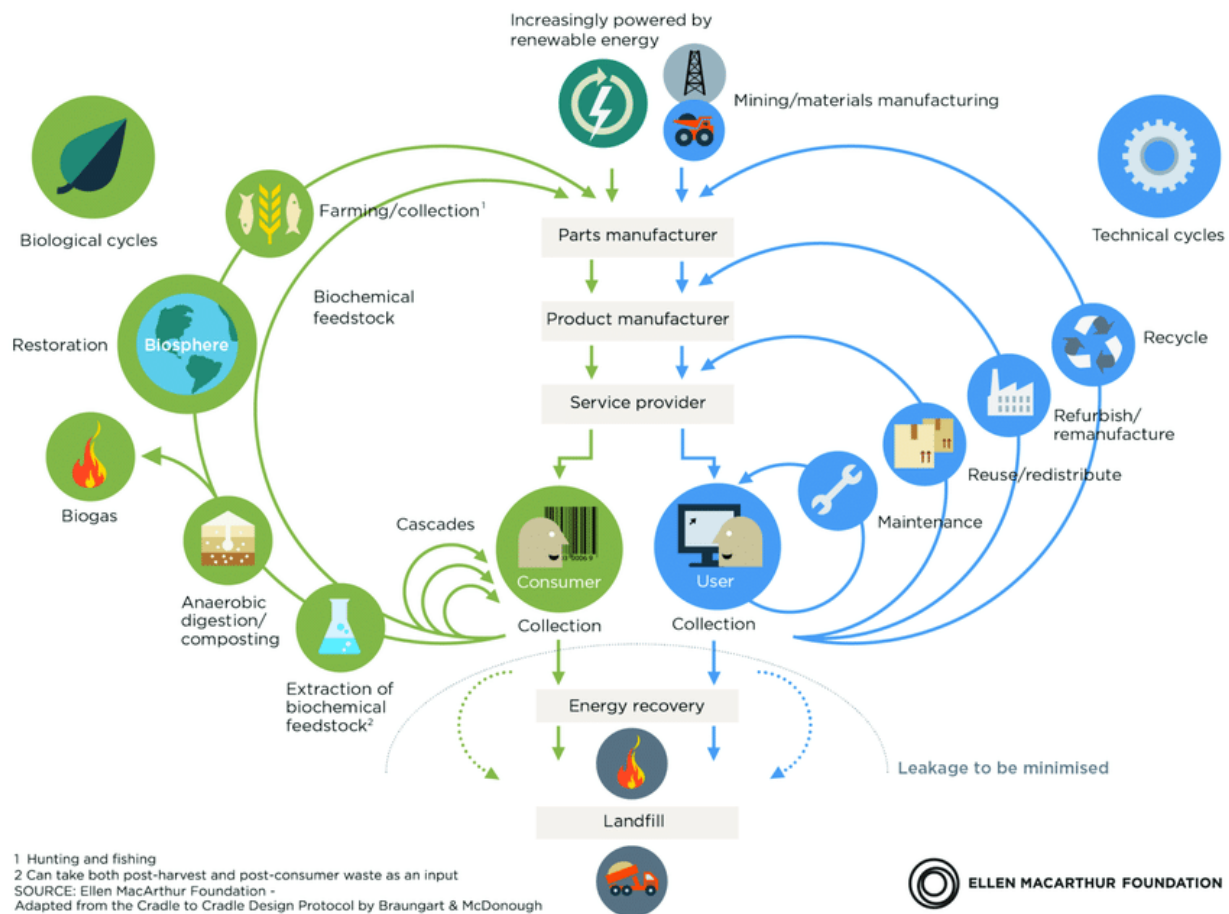


Figure 2: Circular Economy Paradigm (Ellen MacArthur Foundation, 2017)

Adopting a circular economy model allows for potentially decoupling economic development from resource consumption, implying that financial growth need not be linked to the extent of primary material and energy used. In a linear economy, goods are sequentially produced, consumed and disposed. Process-efficiency improvements reduce material and energy consumption to a certain extent, but do not address waste creation and accumulation. Moreover, in many cases, waste created is equivalent to resource lost (World Business Council for Sustainable Development, 2017). This issue gains further significance with materials of critical supply, like the cobalt used in battery-packs, both in terms of volume and price. From a corporate standpoint, inefficient processes that also generate substantive waste represent significant financial losses.

The application of such a strategy in automotive manufacturing is warranted, owing to the traditionally resource-intensive production processes of this sector (Ellen MacArthur Foundation, 2013). The reliance of automakers upon raw materials and certain non-abundant/dispersed elements remains a supply chain management issue. Documented shortages and supply-related problems of some metals, coupled with rise in global demand for raw materials, can lead to significant price escalations. For the mobility sector, these could be very costly. A salient element of circular systems is the presence of recycling loops, which enable displacement of intensive primary (virgin) materials with reusable secondary material (with equivalent functional criteria), while simultaneously offsetting associated costs and magnitudes of waste generated. Another strategy of circular systems involves remanufacturing and reconditioning of capital goods at the end of their service lives. As part of these practices, products are repurposed to near-original quality for 'second-life' use, be it in the same system, or an alternative one. One way automotive OEMs deploy these strategies is through take-back

programs for used cars. Further, similar to lead-acid batteries, they could recycle lithium-ion packs to reduce environmental impacts from fabricating new units (Toffel, 2003).

Ford has already implemented many circular economy programs and initiatives throughout the various stages of a vehicle's life cycle. The second half of our study documents and maps these programs and initiatives into one diagram based on the Ellen MacArthur Foundation's circular economy framework. This diagram would be useful for several reasons. First, no automobile manufacturer has demonstrated how their sustainability goals fit into the circular economy paradigm. The diagram would be the first in the industry to create a representation of how a circular economy currently works for an automotive OEM. Second, this diagram would be a comprehensive representation of existing circular economy efforts at Ford. This is beneficial as the various sustainable efforts managed across several departments will be displayed in a single, easy to interpret diagram. Not only is this useful for the company internally to have the information consolidated, but it can also benefit consumers who are trying to educate themselves about sustainability at Ford. Finally, an integrated representation of Ford's circular efforts will allow them to better identify gaps in and improve on their sustainability strategies.

2. Objectives/Deliverables

The project was divided into two phases. The Scope 3 phase entailed building on Ford's existing Scope 3 emissions inventory. As a means of reducing Scope 3 emissions we undertook the Circular Economy phase, which involved documenting various sustainability programs and initiatives at Ford and integrating them into the Ellen MacArthur Foundation's visual framework for a circular economy. Through a better estimation of Scope 3 emissions in the first phase, and a comprehensive representation of Ford's circular economy initiatives in the second phase, we aimed to provide the company with the guidance needed to inform their future emissions-reduction strategies. Specific objectives for each phase are listed below:

2.1 Scope 3 Phase

1. Benchmark industry leaders in Scope 3 CDP reporting and associated sustainability programs and initiatives. Identify best-practices and methodologies for Ford to incorporate.
2. Improve on Ford's existing Scope 3 emissions protocol for better estimating their indirect GHG inventory.
3. Provide recommendations for enabling a more complete, accurate, and transparent Scope 3 CDP submission for 2018 and 2019.

2.2 Circular Economy Phase

1. Identify sustainability programs and initiatives throughout Ford that fit the circular economy paradigm.

2. Map these programs and initiatives into a comprehensive circular economy framework and show the key material and energy flows within the life cycle of a vehicle. Develop the figure for potential publication in Ford's 2019 corporate sustainability report.

3. Scope 3 Emissions Mapping

3.1 Methods

Leaders in Scope 3 CDP reporting were benchmarked against Ford’s 2017 baseline. Automotive OEMs as well as cross-sectoral companies recognized for their best practices in reporting Scope 3 emissions and associated sustainability initiatives were evaluated (**Table 1**):

Table 1: Benchmarked companies and 2017 CDP scores

	Company	CDP Score
Automotive OEMs		
1	Ford Motor Company (Ford)	A-
2	General Motors Company (GM)	A-
3	Fiat Chrysler Automobiles NV (FCA)	A-
4	Volkswagen AG (VW)	A-
5	BMW AG (BMW)	A
6	Toyota Motor Corporation (Toyota)	A
7	Honda Motor Company (Honda)	A-
8	Nissan Motor Co., Ltd. (Nissan)	A-
Other Industries		
9	Wal-Mart Stores Inc. (Wal-Mart)	B
10	Apple Inc. (Apple)	A
11	Microsoft Corporation (Microsoft)	A
12	Unilever plc (Unilever)	A
13	Starbucks Corporation (Starbucks)	B

Relevant data and information from these companies were collected by reviewing their most recent corporate sustainability reports (publicly available on the companies’ websites) and their CDP Climate Change reports (publicly available on the CDP website). Subsequently, we

analyzed adopted practices and methodologies to report Scope 3 emissions, reviewed environmental targets, and identified the actions taken to engage with stakeholders in their value chains. The major criteria we developed for benchmarking purposes were:

1. Absolute (in mt CO₂e) and normalized (in mt CO₂e per unit sold) Scope 3 emissions
2. Scope 3 absolute and intensity targets and emissions-reduction initiatives
3. Number of Scope 3 categories reported and rationale for those categories not reported
4. Methodologies for reporting each Scope 3 category
5. 3rd party verification or assurance process, if in place
6. Sustainability initiatives related to indirect emissions
7. Engagement with value chain partners

After assessing each company for the stated criteria, we highlighted Ford's relative positioning/performance, identified possible improvements, and suggested methodologies for Ford to incorporate in the short, medium, and long-term. All our observations were synthesized, which allowed us to compare key methodology differences of the most significant Scope 3 categories that could be improved for Ford's future CDP submissions. Comparing Ford's performance relative to other companies, we provided recommendations for enabling more complete, accurate, and transparent Scope 3 CDP submissions.

3.2 Benchmarking Takeaways

This section describes the primary takeaways from benchmarking each company against Ford's performance based on the aforementioned criteria. The conclusions derived for each criterion are described in the Proposed Recommendations and Results section.

1. Absolute (in mt CO_{2e}) and normalized (in mt CO_{2e} per unit sold) Scope 3 emissions

The 2017 CDP Climate Change report for each benchmarked company includes their absolute Scope 3 emissions (incurred in 2016), aggregated in **Appendix B**. Since the number and nature of product-units sold tend to differ, not only across sectors, but also between automotive OEMs, a direct comparison of absolute Scope 3 emissions was avoided. For instance, some automotive manufacturers included miscellaneous product lines in their Scope 3 reporting, such as motorcycles and power products (e.g., generators, snow throwers, lawnmowers, pumps, etc.). However, one salient takeaway from absolute Scope 3 emissions was that the category with the highest emissions for every automotive manufacturer was ‘Use of Sold Products’, which represented an estimated 70% to 90% of the total Scope 3 emissions, followed by ‘Purchased Goods and Services’, which represented an estimated 8% to 22% of the total Scope 3 emissions. For non-auto manufacturers benchmarked, Microsoft and Unilever also had the highest emissions from Use of Sold Products, albeit with lower proportions of total Scope 3 emissions (47.17% and 62.82%, respectively). Contrarily, for Wal-Mart, Apple, and Starbucks, the highest emissions were attributed to Purchased Goods and Services (95.79%, 77.07% and 65.35%, respectively), due to the types of consumer goods they produce.

Use of Sold Products includes emissions from the use of goods and services sold by the reporting company in the reporting year, as well as the Scope 1 and Scope 2 emissions of end-users, who are the consumers and business customers that use final products (World Resources Institute, 2011). For automotive OEMs, this category covers emissions generated by the use of the automobiles they sell to their customers. In the 2017 CDP, this category represented approximately 90% of Ford’s total Scope 3 emissions. The Purchased Goods and Services category includes all upstream (i.e., cradle-to-gate) emissions from the production of products

purchased or acquired by the reporting company in the reporting year. Cradle-to-gate emissions include those that occur in the life cycle of purchased products, up to the point of receipt by the reporting company (World Resources Institute, 2011). For automotive manufacturers specifically, this category includes emissions that occur in the life cycle of automobiles, up to the point of receipt by the company (i.e. emissions associated with the supply chain from material extraction through manufacturing). In the 2017 survey, this category represented roughly 9% of Ford's total Scope 3 emissions.

To perform a direct comparison between automotive OEMs, we normalized the Scope 3 emissions using the total units sold in 2016 as a basis, which was obtained from each OEMs' annual financial reports. **Appendix C** shows the normalized Scope 3 emissions by category. In 2016, Ford sold 6,651,000 automobiles (Ford Motor Company, 2017). Ford's cumulative normalized Scope 3 emissions were 22.11 mt CO₂e per unit sold, the lowest among all the automotive manufacturers benchmarked. We attributed part of this to the fact that Ford was underestimating emissions in major Scope 3 categories, including Purchased Goods and Services and Use of Sold Products. Furthermore, Ford reported emissions in the fewest number of categories (after BMW), although many of the categories excluded were expected to have relatively small impacts. **Table 2** shows the total absolute and normalized Scope 3 emissions, as well as the total units sold in 2016 by each one of the benchmarked automotive OEMs.

Table 2: 2017 CDP total absolute and normalized Scope 3 emissions for automotive OEMs

Company	Total Absolute Scope 3 Emissions in mt CO₂e	Total Units Sold in 2016	Total Normalized Scope 3 Emissions in mt CO₂e/Unit Sold
Ford	147,035,685	6,651,000	22.11
GM	320,894,122	9,965,238	32.20
FCA	109,054,122	4,482,000	24.33
VW	327,983,298	10,300,000	31.84
BMW	70,006,085	2,367,603	29.57
Toyota	367,795,669	8,681,000	42.37
Honda	302,365,341	3,636,000	58.21
Nissan	150,462,000	5,626,000	26.74

2. Scope 3 absolute and intensity targets and emissions-reduction initiatives

Through the CDP Climate Change questionnaire, companies disclose their Scope 3 absolute and intensity-based reduction targets. An absolute target is expressed as a reduction in GHG emissions to the atmosphere over time in units of mt CO₂e. An intensity target is expressed as a reduction in the ratio of GHG emissions relative to a business metric, such as output, production, sales or revenue (World Resources Institute, 2011). Companies can set targets for total Scope 1, 2, and 3 emissions, a single target for total Scope 3 emissions or separate targets for individual Scope 3 categories. Independent of how companies set targets, they are required to have a completion date and a targeted level of reduction. CDP incentivizes reduction goals that are approved by the Science-Based Targets initiative (SBTi), wherein targets are aligned with the level of decarbonization required to keep global temperature increase below 2°C compared to pre-industrial levels (Science Based Targets, 2018). Although not mandated, companies can have

their targets approved by the SBTi for ensuring commitment and transparency, and also obtaining higher scores in their CDP submission.

In their 2017 CDP Climate Change submission, Ford stated an intensity target for the Scope 3 category Use of Sold Products. This target aims to decrease 48% of the emissions in this category by 2030, relative to the base-year of 2010. While modeled as an SBT, this target has not received institutional approval from SBTi yet. Ford does not have an absolute target for reducing Scope 3 emissions. Similarly, GM set intensity targets for GHG emissions from Use of Sold Products, defining different targets based on their largest markets: 15% decrease in United States by 2016, from the base year of 2011; 27% decrease in the European Union by 2020, from the base year of 2011; and 28% decrease in China by 2020, from the base year of 2013. GM anticipated setting an SBT within two years. BMW also set an intensity-based target for the same category, aiming to decrease 25% of these GHG emissions by 2020, from the base year of 2008. Their target was not approved by the SBTi.

VW has an absolute target for Use of Sold Products, which aims to decrease 45% of the emissions in this category by 2020, relative to 2006. This target was not approved by the SBTi. Honda and Nissan were the only two companies benchmarked who have both intensity-based and absolute reduction targets for their Scope 3 emissions. Honda set an absolute target for their Scope 1, 2 and 3 emissions, to decrease CO₂ emissions from all their product lines by 30% by 2020, compared to 2000 levels. The company's intensity target for the Use of Sold Products category was to decrease emissions by 30% by 2020, from the base year of 2000. Honda anticipates setting science-based absolute and intensity targets within the next two years. Nissan's absolute target for their Scope 1, 2 and 3 emissions was the farthest reaching, targeting a 70% decrease of well-to-wheel (WTW) CO₂ emissions by 2050, compared to 2000 levels. The

company's intensity target for Use of Sold Products was a 35% reduction in GHGs per kilometer by 2016, compared to 2005. Both targets were designed as SBTs, but were not yet approved. FCA and Toyota were the only benchmarked automotive OEMs who had not set targets. From the benchmarked non-auto manufacturers, Wal-Mart, Apple, and Microsoft set absolute targets but only Wal-Mart's targets were approved by the SBTi. Unilever disclosed intensity targets, while Starbucks had no Scope 3 emissions-reduction target.

In summary, from all the 12 benchmarked companies, three companies presented Scope 3 intensity targets, four companies presented Scope 3 absolute targets, two companies presented a combination of both targets, and three companies did not indicate any target.

3. Number of Scope 3 categories reported and rationale for those categories not reported

When disclosing their Scope 3 emissions to the CDP, companies have to segment them in 15 categories (sources). If the companies choose to report under a certain category, they have to determine the evaluation status as “relevant, calculated”, or “not relevant, calculated”; if not, they have to choose between “relevant, not yet calculated” or “not relevant, explanation provided”. If emissions are calculated, companies have to disclose them in mt CO₂e, provide the calculation methodology, and present the percentage of emissions calculated using data obtained from suppliers or value chain partners. Finally, for those categories which are deemed as “not relevant, explanation provided”, a short explanation is to be presented (CDP, 2018). When reporting to the CDP, companies have the freedom to define their own threshold of Scope 3 category relevance. Although the CDP awards equal score to categories that are “relevant, calculated”, “not relevant, calculated”, and “not relevant, explanation provided”, for the sake of

transparency, companies should consider providing numerical estimates regardless of their determination of relevancy.

Table 3 shows the number of Scope 3 categories reported in the 2017 CDP by each of the benchmarked companies. GM was the only company that reported in all 15 categories. For automotive OEMs, the categories least reported were Upstream Leased Assets, Franchises, and Investments. Ford did not report Fuel- and Energy-Related Activities, Upstream Leased Assets, Processing of Sold Products, End-of-Life Treatment of Sold Products, Downstream Leased Assets, Franchises, and Investments in their 2017 CDP submissions, and instead deemed them ‘not relevant’ and provided a supporting explanation.

Table 3: Scope 3 categories reported by benchmarked companies

	Purchased goods and services	Capital goods	Fuel-and-energy-related activities	Upstream transportation and distribution	Waste generated in operations	Business travel	Employee commuting	Upstream leased assets	Downstream transportation and distribution	Processing of sold products	Use of sold products	End of life treatment of sold products	Downstream leased assets	Franchises	Investments	Other (upstream)	Other (downstream)
Ford	Relevant, calculated	Relevant, calculated	Not relevant, explanation provided	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
GM	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
FCA	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
VW	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
BMW	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
Toyota	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
Honda	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
Nissan	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
Wal-Mart	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
Apple	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
Microsoft	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
Unilever	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated
Starbucks	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated	Relevant, calculated

Relevant, calculated

Not relevant, explanation provided

Not evaluated

Relevant, not yet calculated

Did not disclose

4. Methodologies for reporting each Scope 3 category

The CDP Climate Change questionnaire asks that companies calculate (in mt CO₂e) all 15 Scope 3 emissions categories, if applicable, and present a description of the methodology utilized. The WRI published the *Technical Guidance for Calculating Scope 3 Emissions*, which provides information for companies to determine their Scope 3 emissions, including possible methodologies for calculating GHG emissions for each of the 15 Scope 3 categories (ranked in order of specificity), data sources (activity data and emission factors), data collection guidance, calculation formulas, and worked examples. According to this report, calculation methods within each category are to be selected based on the following criteria:

- The relative size of the emissions from the Scope 3 activity
- The company's business goals
- Data availability
- Data quality
- The cost and effort required to apply each method
- Other criteria identified by the company

The decision of selecting the most appropriate method is left to each company, insofar as it reflects the GHG emissions of their activities within each category. Additionally, more precise methods should be considered for those categories that generate the largest amount of emissions (e.g., Use of Sold Products for automotive manufacturers), or those that are most relevant to the company's business goals.

For our analysis, we identified the methodology differences amongst the benchmarked companies, which allowed us to compare the calculation methods of the most significant Scope 3 categories for Ford. **Appendix D** shows the Scope 3 methodology buckets that we developed for each of the Scope 3 categories, wherein we briefly mention the most utilized methodologies and the corresponding companies to have employed them. From all Scope 3 categories, we observed

key differences in 5 categories, using Ford's methodologies (or lack thereof) as the basis. Note that these methodology differences are independent of any differences in resultant emissions:

- Purchased Goods and Services

Ford reported this category using the emissions data reported voluntarily to them by production suppliers through the CDP Supply Chain Program. Ford opted for this method because it enables a more accurate representation of their emissions inventory and also allows for the tracking of emissions from individual suppliers. By contrast, a Life Cycle Assessment (LCA) and industry average data do not show the same level of granularity. While Wal-Mart and Unilever also utilized this methodology, no automotive OEM in our benchmark did. GM, FCA, Honda, and Microsoft chose the spend-based method, which estimates emissions by collecting data on the economic value of goods and services purchased, and multiplies them by relevant secondary emission factors, such as industry average emissions per monetary value of goods (World Resources Institute & World Business Council for Sustainable Development, 2013). Nissan was the only benchmarked company that utilized the volume-based method, that involved multiplying regional production volumes and material use ratios, and utilizing emission factors to convert each material volume to GHG emissions. Finally, VW, BMW, Toyota, Apple, and Starbucks utilized the LCA methodology, which consists of an evaluation of the potential environmental impacts of a product system throughout its life cycle.

- Capital Goods

Ford reported emissions from Capital Goods using the data reported voluntarily by a small subset of their suppliers through the CDP Supply Chain Program. Ford was the only benchmarked company that used this methodology. Half of the benchmarked companies (GM,

FCA, Honda, Toyota, Nissan, and Microsoft) utilized the spend-based method. VW and Starbucks selected the Economic Input-Output analysis method, which aims to estimate the materials and energy resources required for, and the environmental emissions resulting from activities in different economic-sectors (Carnegie Mellon University, 2019). Wal-Mart was the only benchmarked company that used an LCA, while BMW, Apple, and Unilever did not calculate the emissions from this category.

- Fuel- and Energy-Related Activities (not in Scope 1 or 2)

Ford, alongside BMW, Apple, and Wal-Mart did not calculate emissions from this category, although they did provide a supporting explanation. Most of the benchmarked companies (GM, VW, Toyota, Honda, Nissan, and Unilever) calculated this category using upstream emission factors (from third party inventories or representative generic databases) and multiplying them by volume or energy consumption for each energy source. In addition to utilizing upstream emission factors, FCA and Starbucks also accounted for emissions from transmission and distribution (T&D) losses. Finally, Microsoft utilized upstream emission factors for purchased electricity, applied a life cycle analysis tool for fuel consumption, and accounted for emissions from T&D losses.

- Employee Commuting

Ford estimated this impact using the US EPA Small Business GHG emissions tool, similar to GM and Starbucks, who used other GHG emissions tools. FCA, VW, BMW, and Microsoft conducted a survey that included questions related to commute distances, means of mobility, and transportation habits of employees. Apple also used a similar survey, while also including demographic data (zip codes) and commute habits. Toyota, Honda, and Nissan used commuter expenses reported by employees and multiplied them by their corresponding emission

factors for the different transportation means. Finally, Unilever was the only benchmarked company that did not report this category.

- End-of-Life Treatment of Sold Products

Ford was the only benchmarked company that did not calculate the emissions under this category, classifying them as being not relevant and providing a supporting explanation. Further, from those benchmarked, 11 of the 12 considered this category as being ‘relevant’. Of the benchmarked companies, 7 (GM, FCA, VW, BMW, Apple, Microsoft, and Unilever) used the LCA methodology. Toyota, Honda and Nissan used regional sales and multiplied them by emission factors relevant for automotive disposal. Starbucks and Wal-Mart (only for South Africa) chose a methodology wherein they utilized waste-treatment specific-emission factors, weight of purchased items and weight of collected e-waste, respectively.

5. 3rd party verification or assurance process, if in place

A 3rd party verification or assurance process gives a level of confidence that the information provided by a company is complete, accurate, consistent, transparent, relevant, and without material misstatements (World Resources Institute, 2011). While this is not mandatory for companies that disclose their emissions to the CDP, it is highly recommended for the legitimacy-value it brings to the company and other stakeholders when making decisions. It is important that the assurer be independent to the company and has no conflict of interest, to increase credibility of the GHG disclosure. Companies can choose the degree of assurance of their Scope 3 emissions (the number of categories or percentage of emissions they want to have verified by a 3rd party assurer).

For their 2017 CDP Climate Change submission, Ford did not have 3rd party verification or assurance in place for their Scope 3 emissions. All the other 12 benchmarked companies had 3rd party assurance in place to some degree. From the automotive OEMs benchmarked, FCA (99%), BMW (99%) and GM (97%) had the highest percentages of Scope 3 emissions verified, followed by VW (92%), Nissan (88%) and Honda (84%). Toyota (51%) verified about half of their Scope 3 emissions. From the non-auto manufacturers benchmarked, Apple and Unilever had all of their Scope 3 emissions verified, while Wal-Mart (2%), Microsoft (1%) and Starbucks (0.13%) had very low degrees of assurance in place.

6. Sustainability initiatives related to indirect emissions

Companies are requested to disclose their emissions reduction initiatives that were active within the reporting year in the CDP Climate Change questionnaire. Reported initiatives and projects may include those for Scope 1, 2, or 3 emissions. Companies are asked to provide a description of these programs, the estimated annual GHG savings, monetary savings, investment required, payback period, and estimated lifetime. Companies with a large numbers of initiatives should prioritize those that have the potential to provide a meaningful contribution to emissions reductions. For our analysis, we only emphasized those initiatives which aimed to reduce value chain (Scope 3) emissions.

In their 2017 CDP disclosure, Ford presented one Scope 3 emissions reduction initiative, the Ford Partnership for a Cleaner Environment (PACE) supply chain program. This program had been in place since 2014, but in 2016 it was expanded to include 40 strategic suppliers. PACE is a Ford initiative through which they provide recommended actions for suppliers to reduce their energy and water use, particulate and GHG emissions, and waste generation.

Participating suppliers are educated about the initiatives that Ford has implemented in their own operations, and are encouraged to set targets and make progress towards these goals.

Of the other 7 automotive OEMs benchmarked, 3 did not report any Scope 3 emissions reduction initiative (FCA, BMW, and Toyota). GM reported three initiatives under “activities” encompassing waste recovery, transportation (fleet), and product design. For instance, under the product design label, they mention their production of low-emission electric vehicles. Nissan presented two initiatives related to behavioral change and product design. VW and Honda submitted one initiative each, pertinent to product design and energy efficiency (building services), respectively. 2 out of the 5 non-auto manufacturers benchmarked did not present any Scope 3 emissions reduction initiative (Wal-Mart and Starbucks). Apple had a high number of initiatives in place: energy efficiency (processes), process emission reductions, energy efficiency (building services), low carbon energy purchase, and waste recovery. Microsoft and Unilever presented two initiatives each; Microsoft under the activities behavioral change and waste recovery, and Unilever under the activities behavioral change and energy efficiency (processes). In summary, most of the activity-types were consistent amongst the benchmarked companies that presented Scope 3 emission reduction initiatives (except Ford): waste recovery (3/7 companies), behavioral change (3/7), product design (3/7), energy efficiency in processes (2/7), and energy efficiency in buildings (2/7).

7. Engagement with value chain partners

By engaging with stakeholders at different levels of the business, Ford can inform sound strategies to meet sustainability challenges and capitalize on associated opportunities. Among their value chain partners, suppliers are a key component of Ford’s strategy for reducing indirect

GHG emissions. CDP asks companies to disclose their engagement on GHG mitigation and climate change strategies with any of the elements of their value chain, as well as the type and the impact of engagement. Specifically, companies are asked to state the number of suppliers with whom they engage and the proportion of the total spend that those suppliers represent.

In the 2017 CDP, Ford detailed their engagement with 250 suppliers, who represented 65% of their total spend. The method of engagement was through the CDP Supply Chain program's Climate Change questionnaire to better understand the GHG emissions and strategies of their suppliers for managing climate risks.

All the other 12 benchmarked companies also presented supplier engagement strategies in their CDP submissions. From the automotive OEMs benchmarked, only FCA and Toyota engaged all suppliers who represented 100% of their total direct and indirect spend. BMW (81%) and Honda (80%), engaged suppliers that represented a higher proportion of their spend (relative to Ford), while GM (60%), Nissan (51%), and VW (43%) had engagement programs with suppliers who constituted a lower fraction of their total spend than Ford. While the CDP quantifies supplier engagement, the nature of this engagement may vary between companies.

GM, VW, BMW, Toyota, and Nissan also utilized the CDP Supply Chain Program to further engage with their supply-base on climate change issues, to identify upstream risks, to improve monitoring and increase their suppliers' resource efficiency, and enable GHG emission reductions. Apart from strategies that automotive OEMs had in common, other observed programs included participating in supply chain organizations, establishing sustainability guidelines for suppliers, on-site supplier audits, hot-spot analyses, workshops, other sustainability self-assessment questionnaires, and providing individualized feedback to suppliers.

3.3 Proposed Recommendations and Results

The following section describes the outcomes for each one of the recommendations proposed regarding Ford's 2018 CDP Climate Change submission (see **Appendix E** for Ford's 2017 and 2018 reported emissions). Note that the recommendations proposed draw from best practices and industry leadership and are not based on prior cost-benefit analyses which ought to be considered in the future. Further, items that have not been included for the 2018 CDP will be subject to further consideration for forthcoming submissions, starting 2019.

3.3.1 Short Term Recommendations

1. 3rd Party Assurance Initiation

Rationale:

Verifying Scope 3 is beneficial to companies as it increases transparency of reporting and validates their calculation methods. Ford did not previously have 3rd party verification for any of its reported Scope 3 categories. However, seeing that all other benchmarked companies had some form of assurance, and that Ford already had systems in place for verifying other emission-sources, it was recommended that they initiate such an undertaking for at least one of its Scope 3 categories, and extend it to other areas in the future.

Outcome(s):

In subsequent conversations, it was determined that Business Travel would be best-suited for external assurance, due to its ease of obtaining verification for the 2018 CDP submission, which is what the company pursued. Upstream Transportation and Distribution may be verified in the future, given Ford's robust reporting in this category.

2. Elaboration on Supplier Engagement

Rationale:

Ford had mentioned its supplier engagement outreach program, PACE, since their 2016 CDP report. It was recommended that they provide more details about other outreach programs, including the Responsible Business Alliance (RBA), and Automotive Industry Action Group (AIAG) to better describe their emissions management efforts with their suppliers. Because Ford is already committed to these efforts, it is advantageous to fully describe these efforts.

Outcome(s):

Ford incorporated the proposed recommendation in the 2018 CDP by describing their engagement with the RBA, alongside continued mentions of PACE, as pathways for them to mitigate upstream climate change risk. Compliance with ISO standards has also been mentioned in the CDP as a strategy for Ford to be more resource-efficient. There is an untapped opportunity for them to highlight their work with the AIAG. Further, Ford may consider mentioning how suppliers are incentivized for their management of climate change related issues.

3. Mention Waste Minimization as a Scope 3 Emissions Reduction Initiative

Rationale:

Some of the benchmarked companies (GM and Apple) described waste minimization activities as Scope 3 emissions reduction initiatives. Ford currently has 50 zero waste-to-landfill manufacturing sites (CDP, 2018). The avoided waste, reused and recycled materials in these sites results in a reduction of Scope 3 emissions in the Waste Generated

in Operations category. It was recommended that Ford list this program as a Scope 3 emission reduction initiative, specifically mentioning their closed loop aluminum recycling.

Outcome(s):

Ford now mentions closed loop aluminum recycling as an example of waste management in the corresponding Scope 3 section. Subsequent reductions in GHG emissions are also indicated.

4. Fuel- and Energy-Related Activities

Rationale:

All benchmarked automotive manufacturers (with the exception of BMW) besides Ford reported in this category. Because several competitors report in this category, it was recommended that Ford follow suit by applying an upstream emission factor for all fuel consumed and accounting for losses in T&D.

Outcome(s):

Although unlike most other benchmarked automotive OEMs, Ford previously did not report Scope 3 emissions from Fuel- and Energy-Related Activities, they do so now for the first time in the 2018 CDP. An estimate of 1,100,000 mt CO₂e was calculated by applying upstream emission factors and T&D loss-rates from databases like the Argonne National Laboratory GREET model to Ford's Scope 1 and 2 energy inputs. Further, because this represented less than 5% of total Scope 3 emissions, Ford labelled this as being 'not relevant'.

5. Upstream Transportation and Distribution

Rationale:

In their 2017 CDP submission, Ford included a robust framework for managing upstream transportation and distribution, however the phrasing was not intuitive and the methodology for the calculation was not easy to follow. For these reasons, it was recommended that this section be reworded for clarity. Furthermore, the calculations in this section were based on a tank-to-wheel (TTW) methodology for emissions accounting. It was recommended that Ford transition to a well-to-wheel (WTW) methodology to account for the upstream emissions of fuels consumed to be more comprehensive and representative emissions in this category. Using a WTW methodology would allow emissions to be calculated for alternative fuel freight vehicles, whose TTW GHG emissions are relatively lower.

Outcome(s):

As was recommended, the methodology and rationale described for calculating emissions from this Scope 3 category were updated to be more clear and transparent. Further, cumulative GHGs have been broken down into inbound and outbound legs of the transport network. However, WTW emissions have yet not been indicated in the 2018 CDP submission. Since these figures would allow for better encapsulating alternative fuel vehicle-fleets, and are readily available to Ford internally, they should consider reporting emissions from the total fuel cycle in subsequent years.

6. Employee Commuting Data Source

Rationale:

Ford's 2017 CDP report mentioned the calculation tool used in this category but did not mention the source of their data. It was recommended that the source of data and the methodology used be more explicitly stated for the sake of transparency. A statement on the number of employees per region, their mode of commute, assumed mileage, and emissions factors used should be included in the explanation of this category. It was also important for Ford to note that emissions from this category are likely overestimated, as the majority of their employees (84%) drive Ford or Lincoln vehicles, which are already accounted for under Use of Sold Products (CDP, 2018). Until a survey is conducted with more precise metrics for Employee Commuting, and double-counting can be eliminated, it was recommended that Ford mention double-counting is leading to an overestimated emissions count in this category.

Outcome(s):

Per the recommendation, Ford stated how it obtained data for Employee Commuting in the 2018 CDP. Previously double-counted emissions for employees traveling in purchased Ford and Lincoln vehicles were acknowledged, and the GHG inventory was subsequently updated. As the company further refines their calculations for this Scope 3 category, there is room to specifically highlight factors like regional-average trip distance, mode of transport utilized, and average occupancy.

7. Refrigerant Confinement Statement

Rationale:

The GHG protocol specifically denotes refrigerant leakage as a direct contributor to Scope 3 emissions under the Use of Sold Products category. This is particularly important due to the high global warming potential of refrigerants. It was recommended that Ford qualitatively state their internal design efforts to minimize refrigerant leakage from the air conditioning units in their vehicles.

Outcome(s):

While the recommendation entailed mentioning refrigerant switching and confinement initiatives, and specifically under the Use of Sold Products, Scope 3 section, Ford thought it would be more befitting to mention this as a standalone subsection under Scope 1 emissions, aligned with the layout of the 2018 CDP questionnaire.

3.3.2 Medium Term Recommendations

1. Data Quality Indicators

Rationale:

Several benchmarked companies made references to the quality of the data used to make calculations and the certainty of the results. Specifying data quality can lead to added robustness of inventory data, transparency of reporting, and increase stakeholder confidence in results. The GHG protocol accepts either quantitative or qualitative statements of certainty, though quantitative methods are preferred. It was recommended that Ford state the degree of uncertainty in results, albeit qualitatively, for categories that have a large contribution to their overall Scope 3 inventory. Furthermore, the quality of

the data could be stated as either very good, good, fair, or poor, as indicated by the GHG protocol (see **Appendix F**).

Outcome(s):

In the Scope 3 categories of Purchased Goods and Services and Capital Goods, Ford mentions the reliability of supplier data and plans to update emissions estimates as data quality and quantity increases. However, as a best practice, there is an opportunity to further state data quality, variability, and uncertainty across all categories reported.

2. Determination of Scope 3 Category ‘Relevance’

Rationale:

In Ford’s 2017 CDP report they had defined ‘not relevant’ categories by qualitatively stating that a category had a small footprint. Ford did not have a quantitative threshold to establish category relevance. It was recommended that Ford define a cut-off value for determining the relevancy of a category. Category relevance should be calculated based on a fraction of total Scope 3 emissions. This is a more transparent and justifiable way to determine category relevancy than the method previously employed.

Outcome(s):

For Scope 3 determination, alignment with operational control is indicated once, through the description for the Processing of Sold Products category. Ford now also defines a conventional 5% threshold for determining category relevance (or lack thereof), wherein only those Scope 3 categories whose emissions exceed 5% of the total Scope 3 inventory are deemed to be relevant. Subsequently, the only two ‘relevant’ categories are Purchased Goods and Services (20%), and Use of Sold Products (76%). Capital Goods, Upstream

Transportation and Distribution, Waste Generated in Operations, Employee Commuting, and Downstream Transportation and Distribution -- groups previously deemed relevant -- were now categorized otherwise.

3. Purchased Goods and Services, Capital Goods

Rationale:

In Ford's 2017 CDP submission, in the Purchased Goods & Services, and Capital Goods categories, the data used was obtained directly from a sub-set of suppliers who voluntarily reported data to Ford through the CDP supply chain questionnaire. Ford indicated that their estimation of GHG emissions in this category will continue to improve as the quality and quantity of supplier data increases. While primary supplier data is generally the most accurate method to determine emissions in these categories, Ford acknowledged that it was not comprehensive because only a small percentage of suppliers were surveyed. To increase the completeness of this category, it was recommended that Ford use a hybrid method, where a secondary analysis is used to fill in the gaps where supplier data is not available. Secondary methods could include an Economic Input-Output Life Cycle Assessment (EIO-LCA), where only economic data is needed, or a more comprehensive process-based Life Cycle Assessment (LCA). Although a process-based LCA may be more accurate than an EIO-LCA, it was only recommended as a long-term target because of the extensive amount of information needed, whereas an EIO-LCA could be applied more readily.

Outcome(s):

As recommended, Ford applied a hybrid method, supplementing firsthand data from suppliers with economic emission-factors (mt CO₂e/\$) to increase coverage to 100% of total spend for each of the two categories. The increase in emissions between the reporting years 2017 and 2018 was over 29 million mt CO₂e for Purchased Goods and Services (14% emissions calculated from supplier data). For Capital Goods, this increase in GHGs was over 1 million mt CO₂e (with 11% emissions calculated using supplier data). While this change represents a significantly greater proportion of mapped emissions, such a hybrid methodology only provides approximations, and is not perfectly representative of the actual GHG inventory. Ford should use these updated values as order-of-magnitude estimates to prioritize reductions, and in the subsequent years work towards switching to a comprehensive process-based LCA for these two categories, as recommended.

4. Waste Generated in Operations

Rationale:

Ford was previously using the US EPA Landfill Gas Emissions Model (LandGEM) to calculate their emissions for waste generated in operations. The LandGEM model is an automated Microsoft Excel estimation tool used to assess emission rates from landfill gas. This model is somewhat limited due to generic assumptions in the model and only considers landfill-to-methane waste. It was recommended that Ford use the EPA Waste Reduction Model (WARM) instead, because it is specific to both waste type and waste-

management techniques. This model should provide a more accurate estimate of emissions due to waste.

Outcome(s):

Ford switched from using the US EPA LandGEM to the US EPA WARM model for estimating emissions from management of waste generated in their operations. Doing so enables for accounting for techniques beyond just landfilling. Subsequently, a 474% increase in corresponding Scope 3 emissions were noted between 2017 and 2018. Further, Ford now reports the weight of aluminum waste recycled in the description for this category.

5. Use of Sold Products

Rationale:

In Ford's 2017 CDP report they calculated emissions from Use of Sold Products by using TTW emissions data from cars and light commercial vehicles in the US, the EU, China, Canada, Mexico, Brazil, Australia and India (about 80% of vehicles sold in 2016). A 150,000 km lifetime was assumed in these calculations. Although, 150,000 km is a relatively low figure, this is typically what other automotive OEMs use in their Use of Sold Products calculations for CDP. Ford may want to reconsider updating this number to one that aligns with the actual vehicle-miles traveled (VMT) of their fleet for a more accurate calculation and to display industry leadership by explicitly stating this updated parameter in their CDP submission. To estimate a more accurate mileage, region-specific variability in lifetime VMT should be accounted for, rather than assuming vehicles in all markets will travel the same number of miles over their lifetime. Further, it was

recommended that a WTW emissions factor be adopted for this calculation for comprehensiveness across the total fuel cycle. It is important to account for upstream energy used by vehicles, especially as battery electric vehicles (BEVs), which have no TTW emissions and plug-in hybrid electric vehicles (PHEVs), which have no TTW emissions in electric mode, continue to penetrate the market. Finally, it was proposed that Ford consider expanding their coverage of vehicles in this category beyond 80% of sales by including more vehicle types and more markets.

Outcome(s):

Ford included GHG emissions from US medium-heavy duty trucks in this category for the first time, which amounted to approximately 28 million mt CO_{2e}. However, other elements of the recommendation have not been implemented thus far. While existing sales of electrified vehicles is small, and only a relatively small proportion (13%) of vehicle sales have been excluded, it is important to expand calculations going forward, given how Use of Sold Products is Ford's single largest source of GHG emissions, and also that the company is moving towards a more electrified fleet. Further, estimating WTW emissions would allow Ford to work with external stakeholders to decarbonize their vehicle fuel sources. Finally, with more vehicles on the road offering high-mileage durability, it is important to reconsider the assumption for a lifetime corresponding to 150,000 km.

6. Downstream Leased Assets

Rationale:

Ford had not previously reported in this category, while four of the benchmarked automotive manufacturers did. It was recommended that Ford calculate emissions from leased properties by either applying emission factors specific to energy use, or determine emissions based on payment data. In the case of leased vehicles, a statement is needed explaining that these are already included under the category Use of Sold Products.

Outcome(s):

It was determined that the company defines a downstream leased asset as a Ford-owned facility leased fully or partially to non-Ford tenants. As such, there are very few of these facilities, and hence the combined emissions for those facilities are less than 5% of overall Scope 3 emissions. Subsequently, the description and rationale for this category have been updated in the 2018 CDP submission.

3.3.3 Long Term Recommendations

1. Absolute Target Setting

Rationale:

Absolute target setting is a best-practice suggested by the SBTi. Absolute target setting allows for emissions to be reduced despite fluctuating sales, making them more transparent and credible, and consequently leads to a higher CDP score. Ford had an intensity target (normalized per vehicle), but no absolute target. However, five out of the twelve benchmarked companies had some type of absolute target. It was recommended that Ford approach emissions targets with a dual nature: using absolute targets in

conjunction with their intensity targets. Dual nature targets are important because they decouple emissions from sales. For example, a year with low sales may meet an absolute target without any emission reduction initiatives taking place. Conversely, a year with high sales could be meeting an intensity target but significantly increase total emissions. Having both an absolute and intensity target ensures progress is made in emissions reductions regardless of sales. These dual targets align with Ford's electrification goals by allowing them to reduce overall GHG emissions across their fleet, while maintaining (or increasing) their sales volume.

Outcome(s):

In the 2018 CDP submission, Ford now mentions how they consider absolute emissions in the Use of Sold Products target-setting process, and also why they do not have an absolute reduction target. Setting a GHG reduction target contingent on fleetwide sales requires company-wide discussions. Hence, in the coming years, Ford should pursue these discussions, alongside retaining an intensity target.

2. Science-based Targets Approval

Rationale:

Science-based targets ensure accurate targets are set, show commitment towards setting robust targets, and enable transparency. Although Ford has science-based Scope 3 targets, they have not yet been approved by the SBTi. Because verified targets obtain higher CDP scores, and five of the twelve benchmarked companies have or expect to have science-based targets, it was recommended that Ford seek approval of their targets by the SBTi.

Outcome(s):

Ford is waiting for approval of their target(s) from the SBTi. Until then, they will continue to state conformity, alongside providing a link to the details behind their target-setting process.

3. Scope 3 Management Initiatives

Rationale:

Two specific Scope 3 management initiatives were recommended. First, it was suggested that an internal carbon price should be considered. This is a best-practice risk-management tool as it enables opportunities to offer low-carbon solutions and prepares the company for future policies where carbon may be taxed. Second, vehicle components and materials that are major CO₂ sources should be identified to create a supplier environmental hot-spot analysis. This practice, coupled with an internal carbon price, can aid in sustainable sourcing decisions.

Outcome(s):

Ford changed their CDP response from not anticipating an internal price on carbon to anticipating one in the next two years (2018, relative to 2017). Further, they now explicitly mention identifying energy and carbon hotspots within suppliers/materials as a means for mitigating upstream risk from climate change.

4. Business Travel

Rationale:

In Ford's 2017 CDP report, emissions from business travel were calculated using an emission factor (sourced from the EPA) applied to air and rail miles traveled. It was recommended that Ford also include emissions from all ground transportation for a more robust calculation. If this data were not readily available, in the short-term, a statement should be made explaining that ground-transportation is only a small percentage of overall business travel-spend, an insight gleaned from conversations with internal stakeholders.

Outcome(s):

The recommendation was implemented, with Ford now also accounting for emissions from global rental-car miles. Further, a breakdown of GHGs between air, rail, and road travel is provided.

5. Employee Commuting Surveys

Rationale:

Most of the benchmarked companies used an employee commuting survey to obtain data used to calculate emissions in this category. This is a more precise method of calculation as the distance traveled, vehicle occupancy, and type of vehicle can be accounted for in calculations. Previously Ford only used an average distance, assumed mode of transportation for each region, and did not consider vehicle occupancy. Surveys would yield a significantly more accurate emissions estimate. Furthermore, because the majority of employees commute in Fords and Lincolns, and the emissions from these vehicles are

already considered under Use of Sold Products, these emissions can be excluded from the Employee Commuting category to avoid double counting of emissions. Although a high number of employees surveyed will yield the most accurate results, the GHG protocol does permit this data to be extrapolated if only a small percentage of employees respond to the survey.

Outcome(s):

Ford switched to analyzing employee commute distances by analyzing zip codes for utilization in the 2018 CDP submission. However, current estimates assume that the average vehicle occupancy is one passenger, which may not be representative of global trends. Further, it was determined that previously double-counted GHG emissions between Employee Commuting and Use of Sold Products had to be correctly allocated. Thus, emissions from the 84% employees who drove Fords or Lincolns, as determined by preliminary analysis, was excluded from this category and captured in Use of Sold Products. Subsequently, emissions from Employee Commuting were changed to be not relevant. Going forward, the company is also working towards developing a detailed employee commuting survey, including factors like use of transit services and carpooling, to be rolled-out globally in the coming year.

6. End-of-Life Treatment of Sold Products

Rationale:

In Ford's 2017 CDP submission they did not report in the End-of-Life Treatment of Sold Products category, though all other benchmarked companies did. It was recommended

that Ford begin reporting emissions in this category by either using disposal-specific emission factors applied to regional sales, or a process-based region-specific LCA.

Outcome(s):

Ford estimated emissions from this category, previously unaccounted for, by multiplying its vehicle sales by a disposal emission factor taken from Argonne National Laboratory's GREET model, a commonly-used database with transportation-specific life cycle inventories. This resulted in global emissions of 1.4 million mt CO₂e (deemed 'not relevant' for the CDP response). While greater resolution can be achieved by conducting detailed, region-specific LCA studies, precisely mapping end-of-life GHG emissions is generally not a straightforward exercise.

7. Franchises

Rationale:

Ford has not previously reported in this category, while three of the benchmarked automotive manufacturers had. In Ford's explanation of why they deemed this category not relevant they compared the magnitude of emissions to their Scope 1 emissions. Ford should also make a comparison of emissions in this category to total Scope 3 emissions per convention of the GHG protocol for determining category relevance. Furthermore, it was recommended that Ford report emissions in this category using the average dealership footprint or electricity use, coupled with relevant emission factors.

Outcome(s):

For the first time, Ford reported GHG emissions for this Scope 3 category. Ford's US dealerships were comprehensively analyzed, and based on their utility usage, an annual

average GHG footprint of 600 mt CO₂e per dealership was determined. This emission factor was applied across their 3263 US dealerships, to arrive at approximately 2 million mt CO₂e. Since this emission factor was not representative of worldwide Ford dealerships, owing to substantial variability in global dealership footprint and corresponding utility use (based on region-specific weather), emissions were not extrapolated across the entirety of Ford's dealership base. If this footprint was used for determining global dealership Scope 3 emissions, Ford would have obtained an uncharacteristically large value relative to other automotive OEMs. Going forward, Ford should try and understand region-specific dealership GHG footprints, and expand on the 2018 CDP figure.

3.4 Improvements in Reporting

In Ford's 2018 CDP submission they reported 65 million mt CO₂e (43%) more than the previous year (**Figure ES-1**). The majority of the increase in reported emissions is associated with the recommendations that we proposed; implementing some recommendations helped enable Ford to map an additional 63 million mt CO₂e (**Table ES-1**). The increase in reported emissions is from a more complete and accurate accounting of Scope 3 emissions. Ford's sales normalized Scope 3 emissions (32.06 mt CO₂e/unit sold) are now more similar to other automotive OEMs in the 2018 CDP (**Appendix G**). Ford also now calculates emissions in 10 out of 15 Scope 3 categories, two more than the previous year. The increase in calculated Scope 3 categories along with more comprehensive descriptions throughout the 2018 CDP have improved Ford's transparency in Scope 3 emissions reporting.

4. Circular Economy

4.1 Methods

The environmental footprint of a product is associated with the extraction and processing of materials, product performance during use, and disposal (Nicholson *et al.*, 2009). Designing a circular economy through a product life cycle lens, as shown in **Figure 3**, formed the basis of our work. Specifically, vehicle life cycle stages were classified as Materials Manufacturing, Products and Parts Manufacturing, Distribution, Dealership and Servicing, Use, and End of Life (EOL). To indicate specific material and energy flows through (and between) these life cycle stages, loops/arrows, similar to those depicted in **Figure 2**, were incorporated. Further, essential components of a circular system, including renewable energy and biomaterial flows, alongside recycling, repurposing, and remanufacturing loops were identified. Subsequently, relevant Ford programs and initiatives were enlisted, drawing from their annual sustainability report, annual corporate report, annual CDP disclosure, and other media releases.

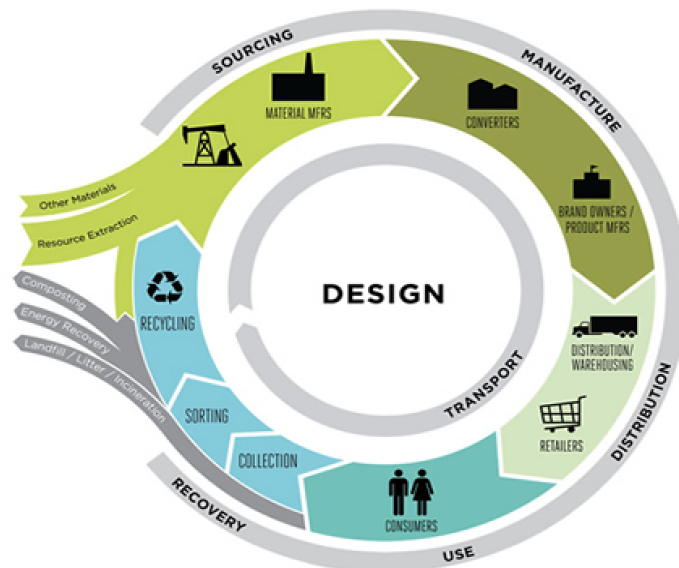
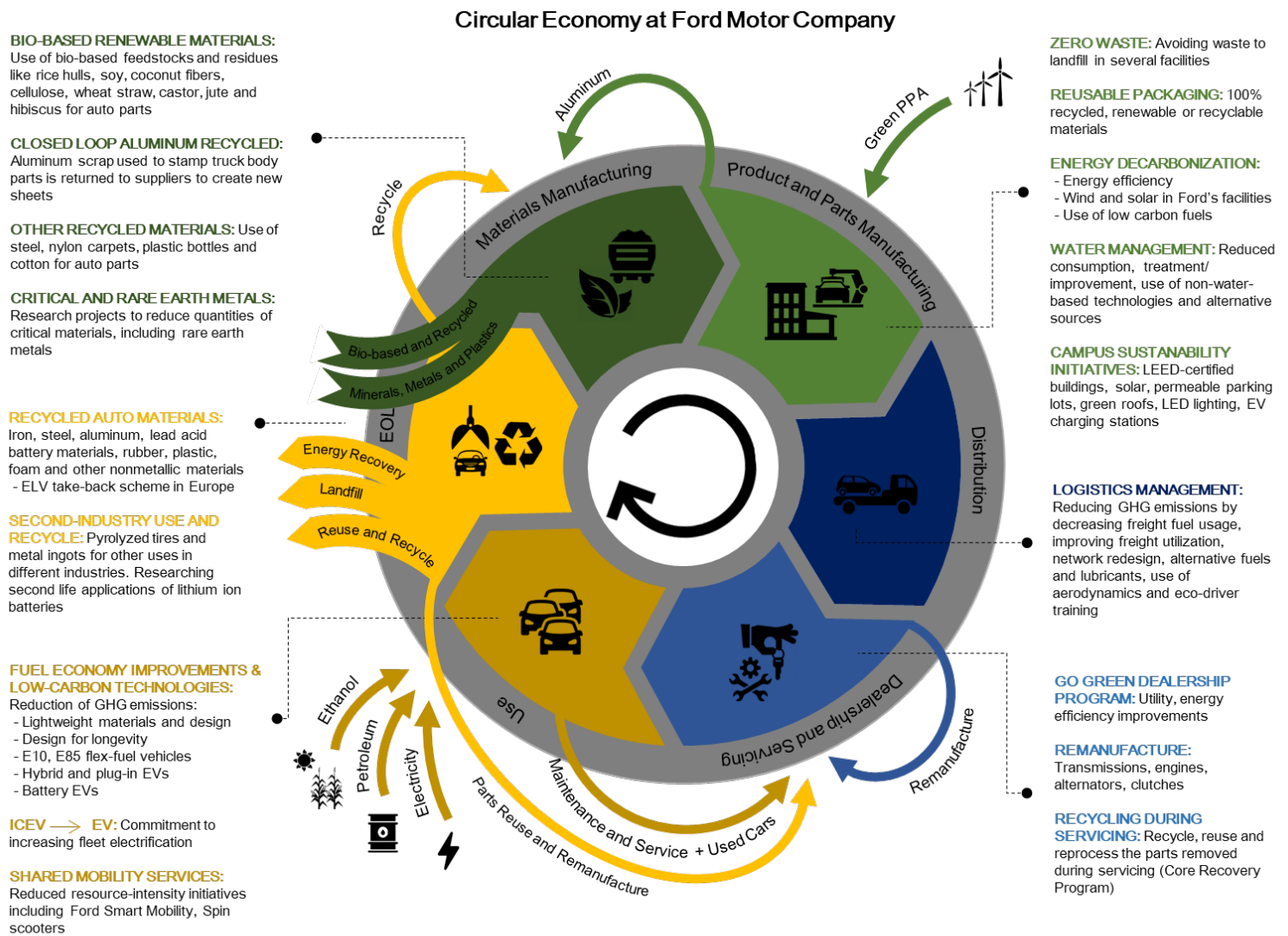


Figure 3: Design of a Circular Economy (GreenBlue, 2019)

The diagram was tailored to include the programs and initiatives identified. Through a series of informational interviews with subject matter experts and internal stakeholders, iterative versions of our schematic were developed. Internal Ford teams engaged included Analytics, High Mileage Durability, Logistics, Sustainable Materials, Environmental Sciences, Remanufacturing, Utilities, and Environmental Compliance. The finalized schematic is shown in **Figure 4**, with each stage of the vehicle's life cycle (as it relates to a circular economy) described below.



EOL: End of Life; ICEV: Internal Combustion Engine Vehicle; EV: Electric Vehicle; ELV: End of Life Vehicles; GHG: Greenhouse Gases

Figure 4: Circular Economy at Ford Motor Company

4.2 Ford's Circular Economy Efforts

4.2.1 Materials Manufacturing

The first phase of the product life cycle is Materials Manufacturing. It includes all the processes and procedures needed to obtain safe and high-quality materials for product and parts manufacturing. Materials selection and manufacturing decisions provide important levers to improve the environmental performance of companies, since these choices impact the environmental performance of a product over its entire life.

Automobiles require a wide variety of raw materials for their production, traditionally including the iron used for steel, aluminum, glass, and the petroleum products used to make plastics, rubber, and special fibers. These raw materials are first mined or otherwise extracted from the earth. Then, production companies turn them into materials that OEMs can use in the production of automobiles. In the past decades, raw materials for auto parts have evolved greatly, becoming more sophisticated, sustainable, better built, and safer; in part due to new technologies and design techniques for more durable and green cars.

Ford recognizes that the materials used in their vehicles are key contributors to their total carbon footprint. The company has been working for decades to design and utilize innovative materials with equivalent or superior performance but with a smaller environmental footprint (e.g. reducing waste and moving away from plastics made from fossil fuels). The circular economy initiatives that Ford has already implemented in the Materials Manufacturing phase are highlighted in **Figure 4** and explained below:

- a. Bio-based Renewable Materials: Ford is already integrating plant-based and renewable feedstock in production vehicles, which are obtained from by-products and residues from

the farming community, and is committed to expanding the applications of such materials and continuing searching for innovative and creative sustainable technologies that can reduce their dependence on petroleum. These renewable materials made from plant-sources have lower environmental impacts, and in some cases can also reduce weight, which helps improve fuel economy (Hall, 2009; Boland *et al.*, 2016). The bio-based renewable materials that are currently used in Ford's vehicles are as follows (Ford Motor Company, 2018):

- Castor: Castor bean oil is used for the nylon fuel lines for most vehicles, and instrument panel soft touch foams on three vehicle lines.
- Soy: Polyurethane-foam based in this material is used in seat backs, cushions and head restraints in every North American-built Ford vehicle, while its oil is also incorporated in exterior mirror gaskets.
- Rice hulls: Used to reinforce plastic in the Ford F-150's electrical harnesses.
- Coconut fibers: Used to reinforce the plastic trunk liners of some vehicles.
- Cellulose: The fibers of this material have been used to replace fiberglass in the armrests of the Lincoln MKX.
- Wheat straw: Used to reinforce the plastic in the Ford Flex's storage bins.
- Hibiscus: Incorporated in plastic door parts in the Ford Escape.

In **Figure 4**, the arrow named "Bio-based and Recycled" going from outside the company (farming community) to the Materials Manufacturing phase represents this initiative.

- b. **Closed Loop Aluminum Recycled:** Closed-loop recycling refers to a production process in which post-consumer waste is collected, recycled and used to make new products in the same system (Geyer *et al.*, 2015). This process reduces waste and uses resources more efficiently. At some Ford factories, aluminum is part of this closed-loop recycling process, wherein aluminum scraps used to stamp truck body parts are returned to suppliers to create new sheets that go into the body frames of four lines of North American Ford trucks. Recycling aluminum requires 95% less energy than producing new aluminum (Ford Motor Company, 2018) and can be reused several times. Ford was the first automotive OEM to mass-produce a vehicle with a high-strength aluminum alloy body, and thus became an industry leader in aluminum recycling (Ford Motor Company, 2019). In the schematic, the arrow going from Products and Parts Manufacturing to Materials Manufacturing represents this process.
- c. **Other Recycled Materials:** Apart from plant-based and renewable materials, Ford is a leader in the research, development, and integration of recycled materials in their vehicles. Following the idea of reducing the environmental impact of their vehicles, the company gives second-life use to many products from other industries, such as:
- **Steel:** As part of the Ford Core Recovery Program (FCRP), dealers send back to Ford select damaged or worn steel parts to be recycled. In the schematic, an arrow going from the End of Life phase to the Materials Manufacturing phase represents this initiative.
 - **Nylon carpets:** Post-consumer recycled nylon carpeting is used in cylinder head covers on the Ford Escape, Fusion, Mustang, and F-150 vehicle models.

- Plastic bottles: Used to make floor carpeting and wheel liners in the Ford Transit and C-Max vehicles, as well as fabrics used in the F-150.
- Cotton: Recycled cotton from T-shirts and denim jeans is used for the interior padding and sound insulation in most Ford vehicles.

In the schematic, the arrow named “Bio-based and Recycled”, going from outside the company (other industries) to the Materials Manufacturing phase depicts this initiative.

- d. Critical and Rare Earth Metals: Ford is actively engaged in reducing the quantities of critical materials (including rare earth metals) and is developing research projects to accomplish that objective. Small quantities of critical materials are found in internal combustion engines, motors and generators, exhaust control systems, batteries for HEVs, PHEVs and BEVs, and other vehicle components. These materials often have significant impact (environmental, social, and economic) with their extraction; hence the importance of reducing their consumption through material use efficiency or material substitution.

4.2.2 Products and Parts Manufacturing

This life cycle stage corresponds to Ford’s Scope 1 environmental impacts, encompassing the manufacture and assembly of vehicles at their facilities after the company receives materials and components from their suppliers. Ford leverages their extended operational control during the Products and Parts Manufacturing phase (relative to other life cycle stages) by deploying a broad-base of circular economy practices, pertinent to material, energy, waste, and water flows. Specifically, the following sustainability programs and initiatives have been implemented:

- a. **Zero Waste:** On a per vehicle basis, Ford has achieved a 61% reduction in waste-to-landfill between 2013 and 2017. Ford currently has 50 manufacturing and 37 non-manufacturing zero waste-to-landfill sites (CDP, 2018). Through their Global Waste Strategy, the company is continuing to reduce the amount of waste sent to landfill every year. At their manufacturing sites, particularly noteworthy for waste-diversion is the closed loop aluminum recycling process used in the production of trucks. Apart from recycling, efficient resource use also enables attaining zero waste targets. For attaining zero waste to landfill (ZWTL) status, Ford requires that absolutely no manufacturing waste from a facility gets landfilled (Ford Motor Company, 2018). Current major waste streams include wastewater sludge; recovered paint solids; packaging waste; and used oils and waste solvent. For ensuring the continued attainment of ZWTL status at Ford plants, a range of waste-reduction initiatives are implemented, including new technology investments; standardization of waste tracking and sorting; emphasis on key waste to landfill sources; and supplier engagement for uptake of eco-friendly packaging. Through Ford's recycling program, they avoid the landfilling of 3 million pounds of grinding swarf (metallic particles, abrasives and oils) each year.

- b. **Reusable Packaging:** Packaging is a key part of the automotive supply chain. Ford's packaging guidelines require supplier-provided packaging to have a neutral or positive environmental footprint, achieved through zero waste to landfill and the use of 100% recycled, renewable, or recyclable materials (Ford Motor Company, 2018). Using standardized containers makes packaging more transferable between suppliers and across programs (Ford Motor Company, 2018). In many locations, Ford has contracts with

packaging providers to collect and store the packaging for their suppliers (Ford Motor Company, 2018).

- c. Energy Decarbonization: Ford reduced facility energy consumption (on a per vehicle basis) by 6.8% between 2014 and 2017 (Ford Motor Company, 2018). Energy efficiency and conservation efforts have also enabled Ford to avoid significant GHG emissions and costs. Further, the company is also working on expanding their use of renewable energy. Specifically, Ford installed 5,900 kW of wind and 1,200 kW of solar in two of their European facilities (CDP, 2018). Their operating plant in Cologne has also signed onto a power purchase agreement (PPA) for low-carbon electricity, denoted by the “Green PPA” inflow in our schematic. Finally, Ford is also working on switching to cleaner-burning fuels in some of their facilities.

- d. Water Management: Water is critical to Ford’s business; parts of their operations, such as paint shops, are particularly water-intensive (Ford Motor Company, 2018). This issue is even more salient in water-stressed regions of the world such as India, South Africa, Mexico, and Brazil, where Ford has operations. Their long-term water strategy lays emphasis on region-specific solutions, focusing on reducing freshwater use through a combination of lower consumption, on-site treatment, utilization of non-water-based technologies (MQL, Dry-booth, alternative cooling), and tapping into alternative sources of water, such as effluent from other companies. Ford targets reducing water use per vehicle produced by 30% from 2015 to 2020.

- e. Campus Sustainability Initiatives: Ford is a member of the US Green Building Council (USGBC) and supporter of its industry-standard LEED rating system, wherein the company is committed to green buildings in their operations. Ford currently operates 26 LEED-certified buildings around the world. The company strives to implement a range of best-practices in new facilities, from advanced water-treatment and waste-reduction systems to energy-conservation technologies. By 2020, Ford's Research and Engineering Center (Dearborn Campus) will be powered by a LEED-certified combined heat and power (CHP) plant. This facility will also house a 4 MW solar array, a geothermal unit, and a thermal energy storage tank. Further, Ford's Dearborn Truck Plant at their Rouge facility has a 10-acre green roof, which, coupled with a permeable parking lot, aids with stormwater management (Meir, 2019). Ford also offers on-site vehicle charging at many of their facilities to encourage the use of electric vehicles (CDP, 2018). Finally, Ford invested over \$1.3 million at manufacturing sites to install LED lighting fixtures reducing the overall electricity used on-site, while also saving on energy costs (CDP, 2018).

4.2.3 Distribution

Logistical channels for distribution originate both up and downstream of Ford's manufacturing facilities. Upstream, inbound materials and/or components are delivered to vehicle assembly plants. Downstream (post-assembly), outbound (sales-ready) vehicles are sent to Ford dealerships and franchises. Despite not always having complete control of distribution management (owing to outsourcing and contracting), Ford has implemented numerous initiatives that enable better environmental and economic efficiency in this stage of the vehicle's life cycle.

- a. Logistics Management: As part of their corporate business policies, the company deploys specific logistics management strategies to reduce GHG emissions from the distribution phase. Freight fuel usage is decreased by deploying more fuel-efficient vehicles (through aerodynamic and/or powertrain improvements), optimizing network design, and increasing utilization rates of existing routes. Further, where possible, Ford is trying to deploy both alternative fuels and lubricants (with lower environmental impacts) in their freight vehicles. Finally, the company is targeting improvements beyond those of a technical nature, specifically by offering eco-driver behavioral training programs (CDP, 2018).

4.2.4 Dealership and Servicing

At the dealership and servicing stage of a vehicle's life cycle, the automobile is received from the manufacturing facility and then sold to the customer to enter the use phase. This stage also encompasses all maintenance and repair work done on vehicles. This is an important stage within the circular economy as it helps maintain products at a high value (and utility) to keep them in use as long as possible. The longer parts and vehicles can stay in use, the more value that is captured from these products. Throughout the use phase, consumers bring their cars to dealerships and workshops for maintenance, which helps increase the life of their car. When a consumer is ready to purchase a new vehicle, they can then resell their old vehicle back to the dealership (or third-party dealer) for the car to be used again by a new consumer. Re-use can occur for individual parts as well. During servicing, if certain parts fail, they can be removed from the vehicle, remanufactured and then put into another vehicle. Remanufacturing involves replacing the damaged component of the part, repairing it to the manufacturer's specifications,

and placing it inside a new car. Remanufacturing can also be done on parts once a car reaches end of life. Certain parts that do not require remanufacturing, such as bumpers, headlights, and windshield wiper motors can be used from cars that have reached their end of life, provided that they are undamaged. Ford's circular economy initiatives for the dealership and serving stage are as follows:

- a. Go Green Dealership Program: The Ford Go Green Dealership Program was launched in 2010 and currently has over 1,600 participating dealerships, representing about half of the total dealership network (CDP, 2018). Each participating dealership received a detailed assessment identifying where efficiency upgrades could be made resulting in energy savings (CDP, 2018). These assessments provided recommendations regarding lighting efficiency, HVAC systems efficiency, building envelope improvements, and water consumption reduction, and applications for renewable energy (CDP, 2018). The average dealership could potentially reduce their energy consumption by 25% and save 210 mt CO₂e annually if all of the recommendations from the assessment were implemented. (CDP, 2018). Across the entire dealership network about 40,000 mt CO₂e are avoided annually, which could improve to 100,000 mt CO₂e if all participating dealerships were to fully implement all of the recommendations (CDP, 2018).
- b. Remanufacture: Ford performs remanufacturing on transmissions, engines, alternators, and clutches. These valuable parts are remanufactured as they are expensive to manufacture anew. Because remanufacturing is generally less expensive producing than new parts, it is also more economical for consumers. Remanufactured parts can have

relatively long lives as they can go through the remanufacturing process an average of three to four times. However, with each remanufacturing process, reusability decreases. The bulk of remanufactured parts come from cars that are in use, but a small portion also comes from cars that have reached their end of life. Remanufacturing can prevent used parts from entering landfills and avoids the GHG emissions of new parts that would otherwise have to be manufactured as replacements.

- c. **Recycling During Servicing:** Parts that do not require remanufacturing are recycled by dealerships during servicing. Recycled materials are then used to produce new parts. As dealers install new parts during repairs, they can be reimbursed for recycling old parts through the Core Recovery Program.

4.2.5 Use

The vast majority of automobile lifecycle GHG emissions occur in the use phase. These emissions come from two sources: fuel combustion and upstream emissions associated with producing the fuel. It is important to consider the total fuel cycle when evaluating use phase impacts, as it provides the most comprehensive emissions incurred from driving. The total fuel cycle is particularly important when considering battery electric vehicles, as they do not produce any emissions from combustion of fuel but do have associated emissions from electricity generation. Ford has several initiatives aimed at decreasing emissions from Use of Sold Products, which are detailed below:

- a. Fuel Economy Improvements & Low-Carbon Technologies: Ford has deployed several strategies aimed at reducing GHG emissions from their products. These strategies are critical to Ford's 2-degree glide path in which they aim to reduce GHG emissions in accordance to a climate stabilization goal of limiting global temperature increase to 2°C. With yearly fuel economy improvements in each model, Ford reduces impacts from their on-road fleet. Fuel economy improvements are mainly achieved two ways: using lightweight materials in vehicle design, and more efficient engine design. Since 2009, Ford has improved its overall fleet fuel economy by 9% (Ford Motor Company, 2018). Emissions are also avoided through designing vehicles for longevity. The longer a vehicle can remain in use, the longer manufacturing a new vehicle (or parts) can be delayed, avoiding GHG emissions associated with materials manufacturing, product and parts manufacturing, and distribution. It is important to consider the trade-off between longer vehicle use and fuel economy improvements/powertrain advancements in newer models (Kim, Keoleian, Grande, & Bean, 2003). There is an optimal point of replacement where the emissions savings from improvement in fuel economy between a new and old vehicle exceed the emissions from producing a new vehicle. Many Ford models also use alternative fuels as a means to reduce GHG emissions. All of Ford's gasoline vehicles operate on E10 gasoline, which contains 10% ethanol. Because of the lower total fuel cycle emissions associated with ethanol compared to gasoline, GHG emissions are reduced. Furthermore, Ford offers E85 flex-fuel vehicles, which can operate on fuel containing up to 85% ethanol. Ford currently produces hybrid vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and a battery electric vehicle (BEV). HEVs use a gas engine and electric motor, improving fuel economy relative to internal combustion engine

vehicles. PHEVs can use either the gas engine, the electric motor, or a combination of both. PHEVs are able to run in electric mode for a short distances (generally 20-30 miles). BEVs are powered solely by electric powertrains. They do not produce tailpipe GHG emissions, so the major associated emissions are from the electricity generation. In most electrical grids, the upstream emissions from electricity generation are lower than emissions from gasoline combustion (MacPherson, Keoleian, & Kelly, 2012).

- b. ICEV → EV: Ford plans to increase their offering of electrified vehicles to further decrease emissions across their portfolio (Ford Motor Company, 2018). To reach this goal, they will invest \$11 billion, some of which will be deferred from internal combustion engine investment (Ford Motor Company, 2018). By increasing investment in electric vehicles, Ford hopes to stay on track towards goals of China, India, France and the U.K. phasing out internal combustion engine vehicles in between the years 2030-2040.

- c. Shared Mobility Services: By offering shared mobility services, Ford reduces the need for manufacturing more products to satisfy personal ownership. Shared services require smaller fleets than individually owned vehicles, which avoids emissions from manufacturing. Through their Ford Smart Mobility business, the company aims to be an industry leader in connectivity, autonomous vehicles, data analytics, customer experience, and mobility services (Ford Motor Company, 2018). By providing efficient demand-response last-mile mobility solutions, Ford can reduce GHG emissions from status quo transportation. While Ford's Smart Mobility plan expands further, they

currently offer last-mile solutions in the form of Spin scooters. With the recent purchase of Spin, Ford now offers an affordable electrified scooter service that can help reduce urban traffic congestion, parking limitation, and air pollution (Ford, 2018).

4.2.6 End of Life

The last phase of the product life cycle is the End of Life. It includes the disposal and/or recovery of products or components. Traditionally, the business-as-usual scenario involves end of life products being landfilled or incinerated. The alternatives are reuse, recycling or remanufacturing. To minimize the impact of products at their end of life, it is not enough to solely select one or more of these alternatives; the material selection and design of products also defines their end of life management. Automobiles are some of the most highly recycled consumer products because of the recoverable nature of most of their materials. According to data obtained from Ford, vehicles are at least 95% recoverable at their end of life (Ford Motor Company, 2018).

The company has already implemented numerous initiatives to achieve the highest level of economically and environmentally viable recovery of auto parts and components, by selecting recyclable materials and sharing information about the properties of the materials with dismantlers. Specifically, the circular economy initiatives that Ford has already implemented in the EOL phase are:

- a. Second-industry Use and Recycle: Materials recovered from dismantling and shredding can be used as feedstock fractions for other processes or have a secondary use in different industries. Following the objective of reducing the environmental impact of their vehicles

at their end of life, the company is giving a second-life use to certain materials and recycled auto parts, including:

- Pyrolyzed tires: Ford has a patent on the process for the pyrolytic conversion of rubber and plastic wastes to hydrocarbons and the increased conversion of such wastes to products that are useful in other industries (United States Patent, 1985).
- Metal ingots: Certain metallic scrap materials from vehicles are converted into metal ingots, which are recycled and reused in other industries.
- Batteries (lithium ion): Ford is assessing the current landscape of end of life management for all types of lithium-ion batteries used in hybrid and electric vehicles, and identifying opportunities for the North American automotive industry to advance responsible management of such technologies (Suppliers Partnership for the Environment, 2018).

In the schematic, the arrow named “Reuse and Recycle” going out of the company represents this initiative. Those materials that are not reused or recycled are represented by the “Landfill” arrow.

b. Recycled Auto Materials: Damaged, worn, or failed auto parts (e.g. bumpers, headlamp assemblies, engines, and transmissions) are recovered and recycled because of their high value and potential to reduce environmental impacts. Some of the materials that are commonly recycled for creating new materials are:

- Iron and Steel: Iron and steel scrap are recycled and used instead of virgin ore, reducing air and water pollution by more than half during the materials manufacturing process (Viera, 2016).

- Aluminum: Recycled aluminum scrap is returned to suppliers to create new sheets that go into the body frames of four lines of North American Ford trucks.
- Battery materials (lead acid): The company is working to advance responsible battery management at vehicle end of life.
- Rubber: Recycled rubber (from post-consumer tires) is used in underbody covers in a range of Ford vehicles.
- Nonmetallic materials: Ford is developing strategies to divert plastic, foam, and other nonmetallic materials from landfill and using them for energy recovery. This particular initiative is represented in the schematic with an arrow going out of the company named “Energy Recovery”.

In Europe, Ford has a cost-free takeback scheme where Ford collects vehicles at the end of their life from owners. Ford then performs a structured end of life evaluation to determine which parts are suitable for recycling or remanufacturing.

In the schematic, the arrow going from the End of Life phase to the Materials Manufacturing phase represents the aforementioned initiatives.

5. Future Work

Scope 3 categories represent the largest source of GHG emissions for Ford. This project enabled the measurement of a significant quantity of indirect emissions with greater accuracy, transparency, and coverage, for reporting to the CDP. Having begun expanding the measurement of these emissions through a comprehensive assessment protocol, the company can now work towards developing subsequent strategies for the management and reduction of identified GHGs. While the study provides a starting point for Ford to estimate Scope 3 emissions, there is significant future work that should be undertaken for prioritizing areas of reduction, which itself is enabled by comprehensive GHG inventory-building. To that end, mapping Ford's existing sustainability programs and initiatives into an integrated circular economy framework provided the company with valuable insights for prioritizing pathways to reducing carbon emissions.

In the shorter term, Ford should work towards reporting emissions on a total fuel cycle basis where possible. Doing so, they can both identify alternative energy pathways, and work with the providers of these fuels for their decarbonization. The company should continue expanding on positive undertakings, such as an internal carbon price, which can be coupled with material carbon intensities to make sustainable sourcing decisions. Doing so can help reduce emissions from Purchased Goods and Services, which represent 20% of all Scope 3 emissions. Further, tracking more granular data for categories like Franchises and Employee Commuting, as is planned, will allow Ford to make region-specific emissions-reduction decisions. Data uncertainty and need for associated quality improvements should also be explicitly addressed, as these sensitivities may determine whether a category is deemed as 'relevant'.

In the longer term, Ford should focus on the largest Scope 3 categories and those which they have greater influence over. Specifically, Use of Sold Products is the category that the

company should emphasize the most, given that it accounts for about 76% of all Scope 3 emissions in their 2018 CDP submission. Specifically, emphasis must be twofold: better methodologies for estimating GHGs, and subsequent reduction strategies. Holistic measurements can be achieved by accounting for life cycle emissions from vehicles of all powertrains, considering vehicle lifetimes beyond 150,000 km, and accounting for comprehensive fleetwide sales. Next, an absolute reduction target, complementary to the existing intensity-based target, must be defined. For reducing emissions, the company should continue pursuing its existing 1.5°C - 2°C glide path targets, underscore fuel-efficient vehicle production, shared mobility services, electrified powertrain deployment, and lobbying for the decarbonization of vehicle fuel-sources. Doing so, Ford can position itself as an industry leader in both the measurement and management of indirect emissions. Validation may be achieved through extending 3rd party verification to all Scope 3 categories.

Emissions reduction can be achieved by developing strategies using the proposed circular economy visual. All stages of the vehicle life cycle identified in **Figure 4** are sources of Scope 3 emissions, except for Products and Parts Manufacturing (encompasses Scopes 1 and 2). While Ford has sustainability programs and initiatives associated with each of these stages, not all programs have targets and metrics for tracking progress. We recommend that Ford first comprehensively evaluates each of these programs and initiatives for ensuring measurable targets are set and progress is continually tracked. Next, the company should develop another iteration of the circular economy visual with quantifiable flows, similar to a Sankey diagram, wherein the width of the arrows is proportional to the extent of actual material and energy flows. Doing so can provide Ford with a sense of the potential impacts of specific programs and initiatives, represented as arrows and flows, across the vehicle life cycle. Further, the company

should track estimates of avoided GHGs from each sustainability undertaking, which is currently only calculated for a select few programs. Having done so, Ford can conduct a quantitative cost-benefit analysis for prioritizing resources between initiatives as they relate to Scope 3 emissions reduction.

Other variations of the circular economy schematic laying emphasis on social and economic sustainability can be developed to complement our environmentally-focused figure. Finally, potential synergies between initiatives should be identified and developed. For instance, second-life batteries would not only reduce end-of-life emissions, but also displace virgin materials and additional energy required for manufacturing new cells. The ultimate realization of these efforts for Ford can be a future wherein the company is poised to succeed on all fronts of the triple bottom line of sustainability.

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Appendices

Appendix A: Overview of Scope 3 Emission Categories

	Category	Description
1	Purchased Goods and Services	Emissions (cradle-to-gate) from the extraction, production, and transportation of goods and services purchased or acquired by the company
2	Capital Goods	Emissions (cradle-to-gate) from the extraction, production, and transportation of capital goods purchased or acquired by the company
3	Fuel- and Energy-Related Activities	Emissions related to the production of fuels and energy purchased and consumed by the company (fuels, electricity, T&D losses, electricity that is sold to end users)
4	Upstream Transportation and Distribution	Emissions from transportation and distribution of services and products purchased by the company, between a company's tier 1 suppliers and its own operations
5	Waste Generated in Operations	Emissions from third-party disposal and treatment of waste and wastewater that is generated in the company's owned or controlled operations. Includes future emissions generated from waste in that year
6	Business Travel	Emissions from the transportation of employees for business-related activities in vehicles owned or operated by third parties
7	Employee Commuting	Emissions from the transportation of employees between their homes and their worksites
8	Upstream Leased Assets	Emissions from the operation of assets that are leased by the company
9	Downstream Transportation and Distribution	Emissions from the transportation and distribution of products sold by the company between the company's operations and the end consumer
10	Processing of Sold Products	Emissions from processing of sold intermediate products by third parties (e.g., manufacturers) subsequent to sale by the company
11	Use of Sold Products	Emissions from the use of goods and services sold by the company. Include Scope 1 and 2 emissions from end users (consumers and business customers)
12	End-of-life Treatment of Sold Products	Emissions from the waste disposal and treatment of products sold by the company at the end of their life. Includes the total expected end-of-life emissions from all products sold
13	Downstream leased assets	Emissions from the operation of assets that are owned by the company (acting as lessor) and leased to other entities
14	Franchises	Emissions from the operation of franchises (business operating under a license to sell or distribute another company's goods or services within a certain location)
15	Investments	Emissions associated with the company's investments. Applicable to investors (i.e., companies that make an investment with the objective of making a profit) and companies that provide financial services

**Appendix B: 2017 CDP Absolute Scope 3 Emissions for Ford and Other Automotive
Manufacturers**

Emissions in mt CO₂e	Ford	GM	FCA	Toyota	Honda	Nissan	BMW	VW
Purchased Goods and Services	13,133,594	57,929,643	27,837,040	58,689,970	40,084,113	17,914,000	15,391,154	59,415,034
Capital Goods	2,413	4,698,166	1,584,914	3,735,325	1,551,613	1,180,000	Not relevant	13,767,328
Fuel- and Energy-Related Activities	Not relevant	1,423,373	63,639	670,812	454,898	411,000	Not relevant	1,363,103
Upstream Transportation and Distribution	1,502,980	2,938,628	797,648	271,632	2,950,942	809,000	1,427,399	3,795,390
Waste Generated in Operations	22,295	202,937	1,328	63,265	200,174	197,000	Not relevant	2,137,095
Business Travel	57,192	62,671	41,832	183,618	255,344	226,000	166,164	668,894
Employee Commuting	651,750	168,750	9,087	623,029	130,001	304,000	139,797	953,480
Upstream Leased Assets	Not relevant	10,077	0	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant
Downstream Transportation and Distribution	665,461	2,756,687	716,148	275,000	129,831	871,000	Not relevant	Not relevant
Processing of Sold Products	Not relevant	120,731	Not relevant	946,500	32,981	0	Not relevant	13,000
Use of Sold Products	131,000,000	246,249,473	76,971,587	298,183,787	252,588,932	127,666,000	51,079,073	241,679,689
End-of-life Treatment of Sold Products	Not relevant	4,053,236	905,364	3,555,927	3,803,576	423,000	1,185,148	1,606,582
Downstream Leased Assets	Not relevant	20,459	0	Not relevant	Not relevant	461,000	617,350	1,033,703
Franchises	Not relevant	213,190	125,535	Not relevant	Not relevant	Not relevant	Not relevant	1,550,000
Investments	Not relevant	46,101	Not relevant	596,804	182,936	Not relevant	Not relevant	Not relevant
Total	147,035,685	320,894,122	109,054,122	367,795,669	302,365,341	150,462,000	70,006,085	327,983,298

2017 CDP Absolute Scope 3 Emissions for Ford and Non-auto Manufacturers

Emissions in mt CO₂e	Ford	Wal-Mart	Apple	Microsoft	Starbucks	Unilever
Purchased Goods and Services	13,133,594	49,472,163	22,800,000	10,000,000	9,923,385	3,082,115
Capital Goods	2,413	645,328	Not relevant	200,000	1,047,965	Not relevant
Fuel- and Energy-Related Activities	Not relevant	Not relevant	Not relevant	412,039	1,395,658	274,572
Upstream Transportation and Distribution	1,502,980	342,577	350,000	100,000	660,216	379,703
Waste Generated in Operations	22,295	949,497	Not relevant	838	1,329,459	16,954
Business Travel	57,192	54,000	117,500	305,678	20,129	79,991
Employee Commuting	651,750	Relevant/Not Calculated	186,400	200,000	523,015	Not relevant
Upstream Leased Assets	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant
Downstream Transportation and Distribution	665,461	7421	830,000	900,000	Not relevant	1,136,035
Processing of Sold Products	Not relevant	Nor relevant	Not relevant	Not relevant	3,335	Not relevant
Use of Sold Products	131,000,000	Relevant/Not Calculated	5,000,000	11,000,000	88,216	38,664,422
End-of-life Treatment of Sold Products	Not relevant	130	300,000	200,000	196,234	413,478
Downstream Leased Assets	Not relevant	175,500	Not relevant	3,749	Not relevant	Not relevant
Franchises	Not relevant	Not relevant	Not relevant	Not relevant	0	Not relevant
Investments	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant
Other (Upstream)						17,495,890
Total	147,035,685	51,646,616	29,583,900	23,322,304	15,187,612	61,543,160

Appendix C: 2017 CDP Normalized Scope 3 Emissions for Automotive Manufacturers

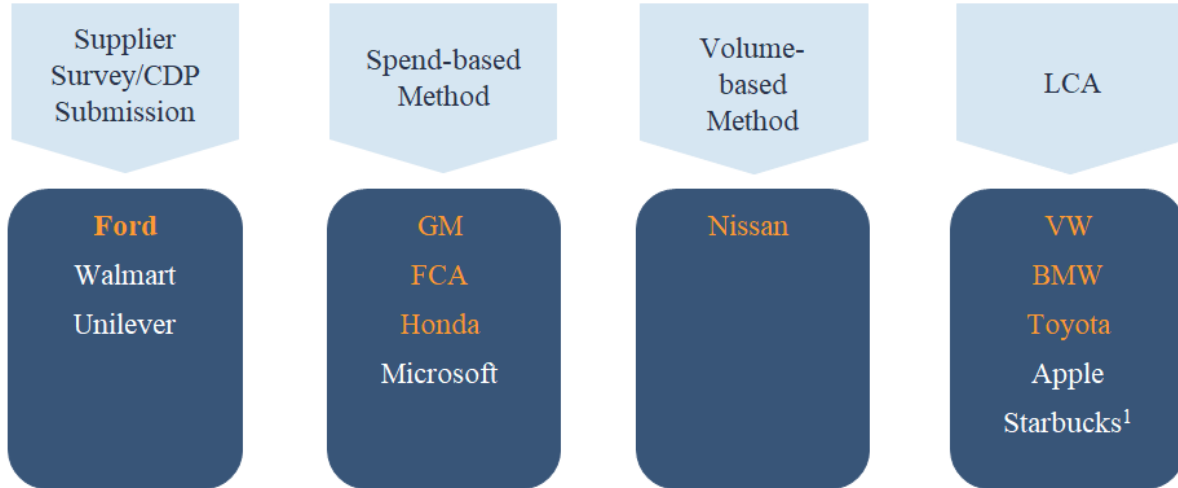
Emissions in mt CO ₂ e/unit sold	Ford	GM	FCA	Toyota	Honda*	Nissan	BMW	VW
Purchased Goods and Services	1.97	5.81	6.21	6.76	7.72	3.18	6.50	5.77
Capital Goods	0.00	0.47	0.35	0.43	0.30	0.21	Not relevant	1.34
Fuel- and Energy-Related Activities	Not relevant	0.14	0.01	0.08	0.09	0.07	Not relevant	0.13
Upstream Transportation and Distribution	0.23	0.29	0.18	0.03	0.57	0.14	0.60	0.37
Waste Generated in Operations	0.00	0.02	0.00	0.01	0.04	0.04	Not relevant	0.21
Business Travel	0.01	0.01	0.01	0.02	0.05	0.04	0.07	0.06
Employee Commuting	0.10	0.02	0.00	0.07	0.03	0.05	0.06	0.09
Upstream Leased Assets	Not relevant	0.00	0.00	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant
Downstream Transportation and Distribution	0.10	0.28	0.16	0.03	0.02	0.15	Not relevant	Not relevant
Processing of Sold Products	Not relevant	0.01	Not relevant	0.11	0.01	0.00	Not relevant	0.00
Use of Sold Products	19.70	24.71	17.17	34.35	48.63	22.69	21.57	23.46
End-of-life Treatment of Sold Products	Not relevant	0.41	0.20	0.41	0.73	0.08	0.50	0.16
Downstream Leased Assets	Not relevant	0.00	0.00	Not relevant	Not relevant	0.08	0.26	0.10
Franchises	Not relevant	0.02	0.03	Not relevant	Not relevant	Not relevant	Not relevant	0.15
Investments	Not relevant	0.00	Not relevant	0.07	0.04	Not relevant	Not relevant	Not relevant
Total	22.11	32.20	24.33	42.37	58.21	26.74	29.57	31.84

Units Sold	6,651,000	9,965,238	4,482,000	8,681,000	3,636,000	5,626,000	2,367,603	10,300,000
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* Automobiles correspond to 70% of the total Scope 3 emissions.

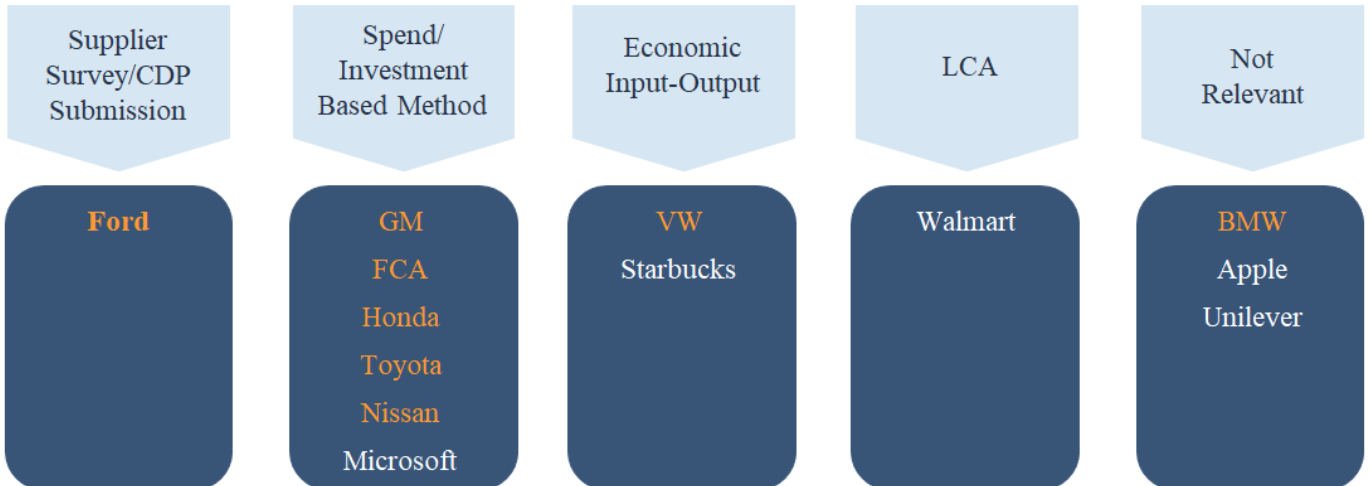
Appendix D: Scope 3 Methodology Buckets

1. Purchased Goods and Services

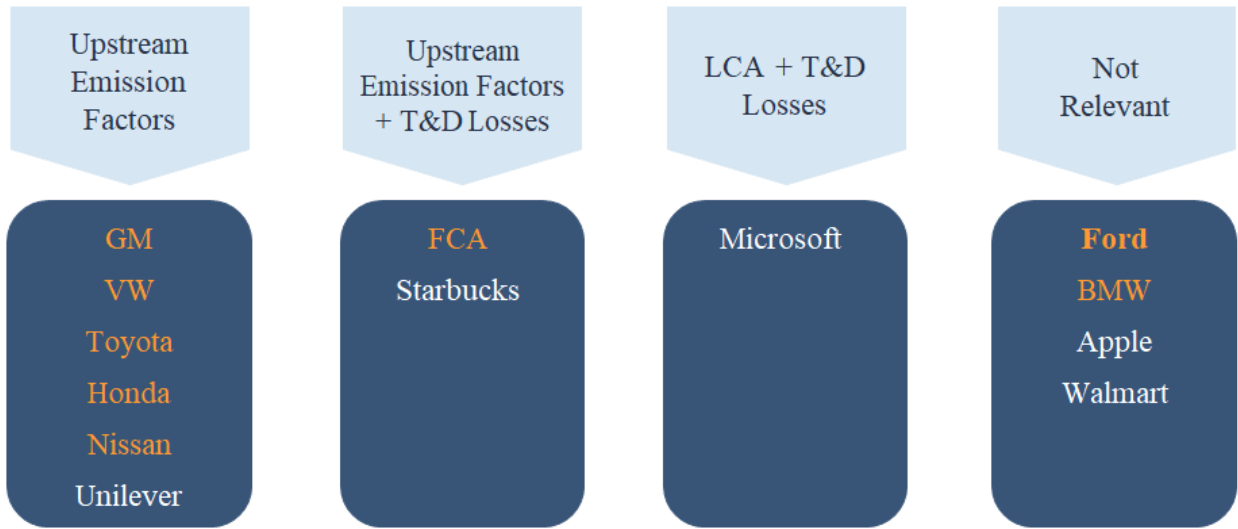


¹ Both Process-Based, Economic Input-Output LCAs for different products

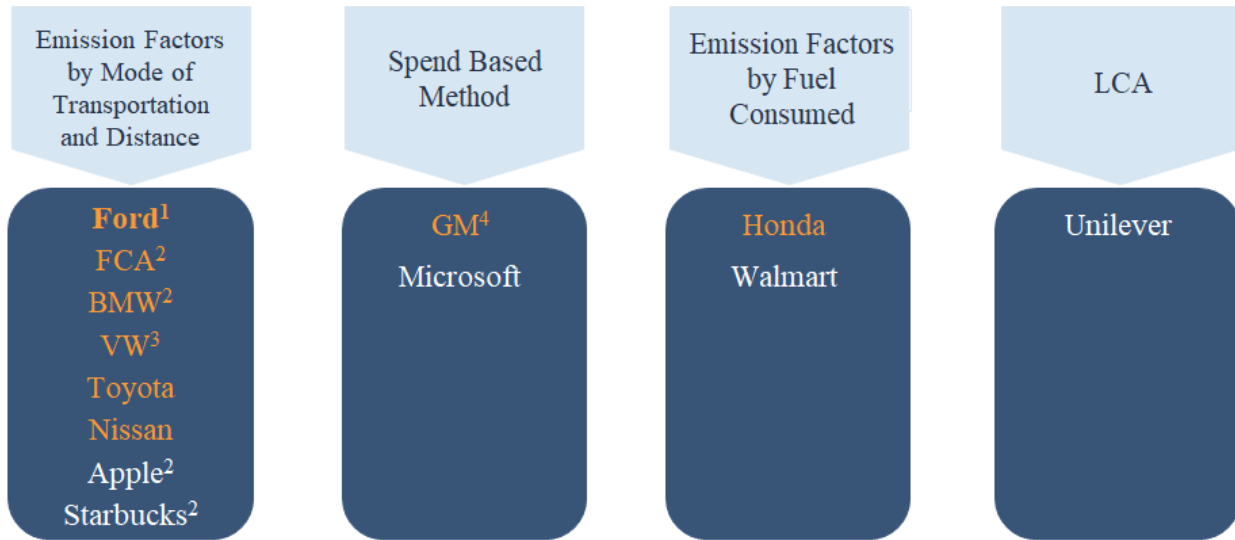
2. Capital Goods



3. Fuel- and Energy-Related Activities



4. Upstream Transportation and Distribution



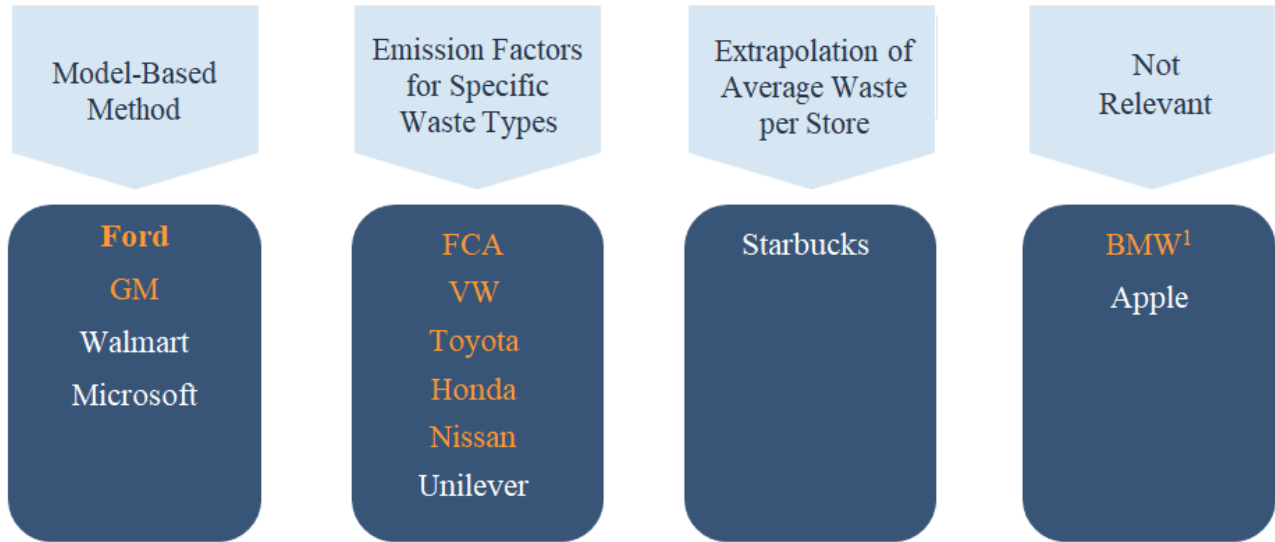
¹ CO₂e emissions per unit vehicle produced

² Uses real activity data

³ Considers well-to-wheel emissions

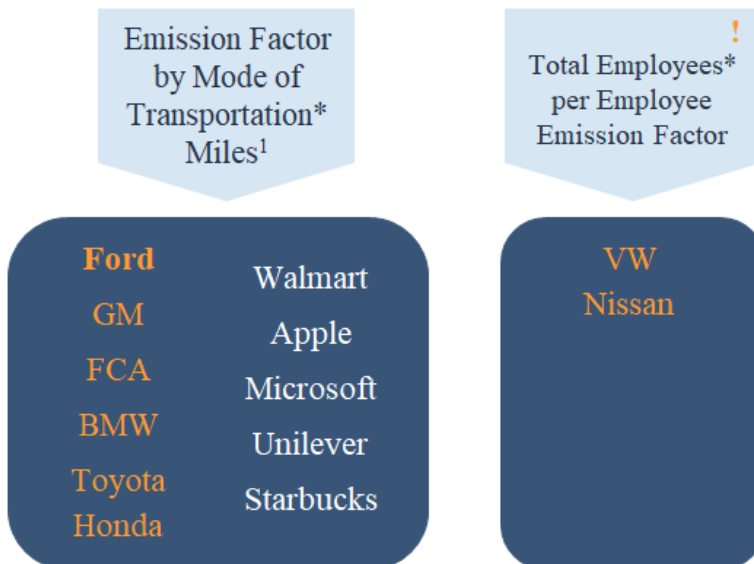
⁴ Distance based method for trucks

5. Waste Generated in Operations



¹ Rough Estimate: Waste categories with emissions factors from LCA inventory

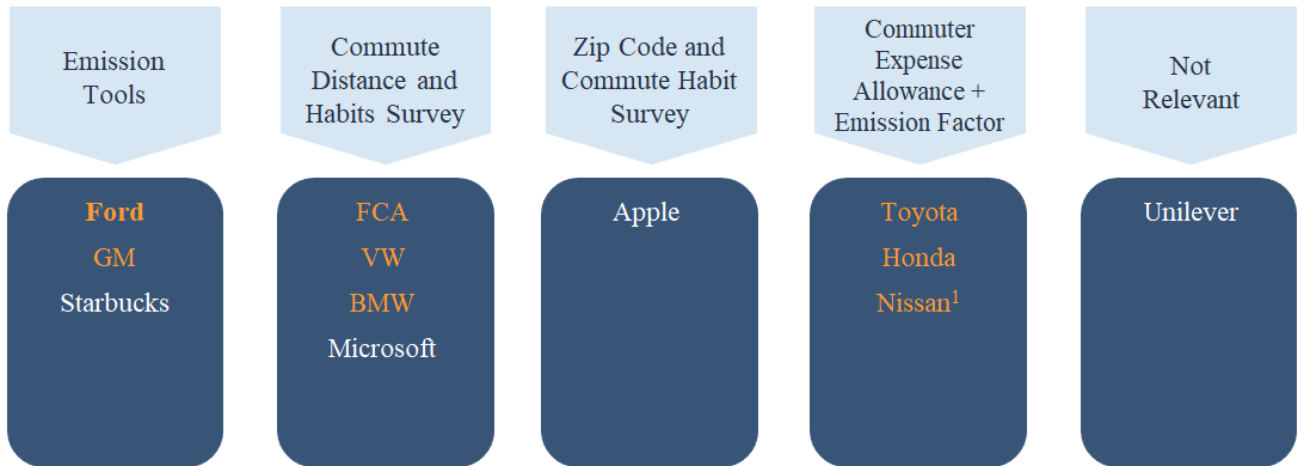
6. Business Travel



¹ Transportation methods included vary by company

! GHG Protocol does not include methodology

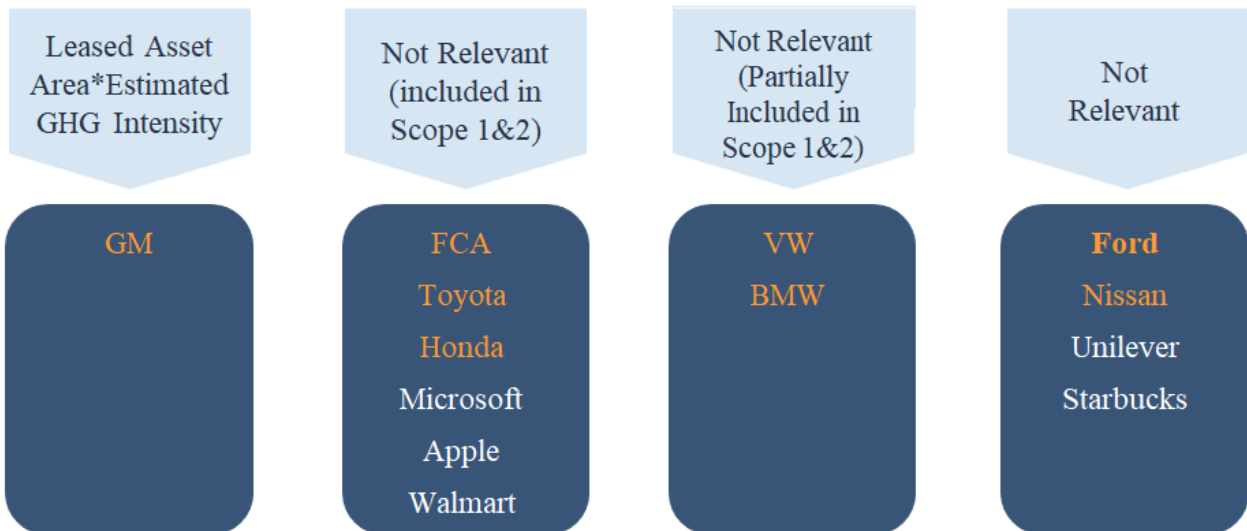
7. Employee Commuting



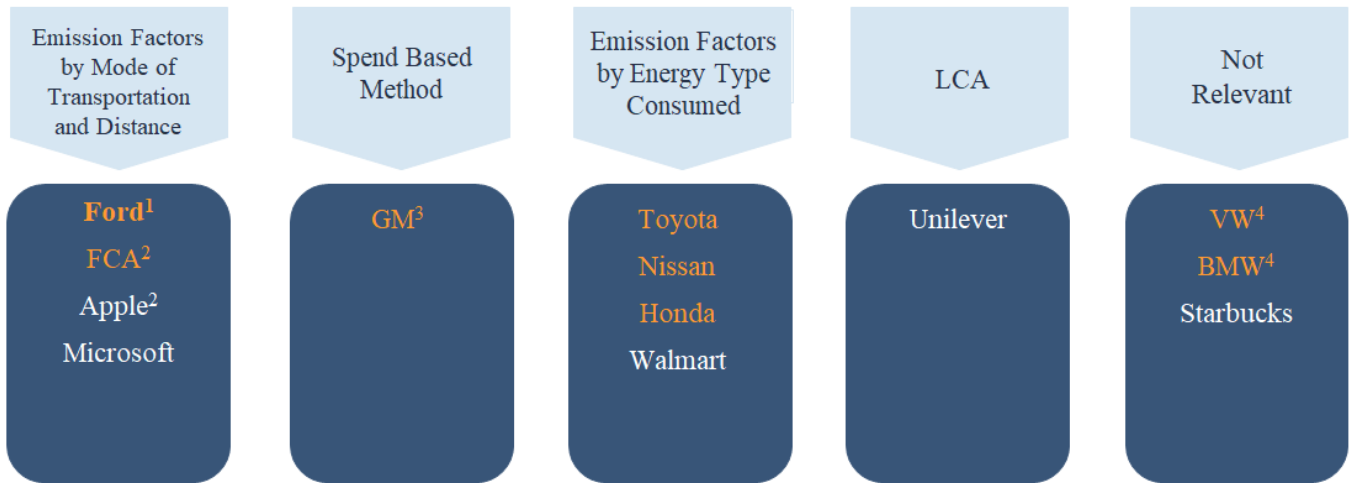
¹ Economic Input-Output LCA

² Walmart: Relevant, yet not calculated

8. Upstream Leased Assets



9. Downstream Transportation and Distribution



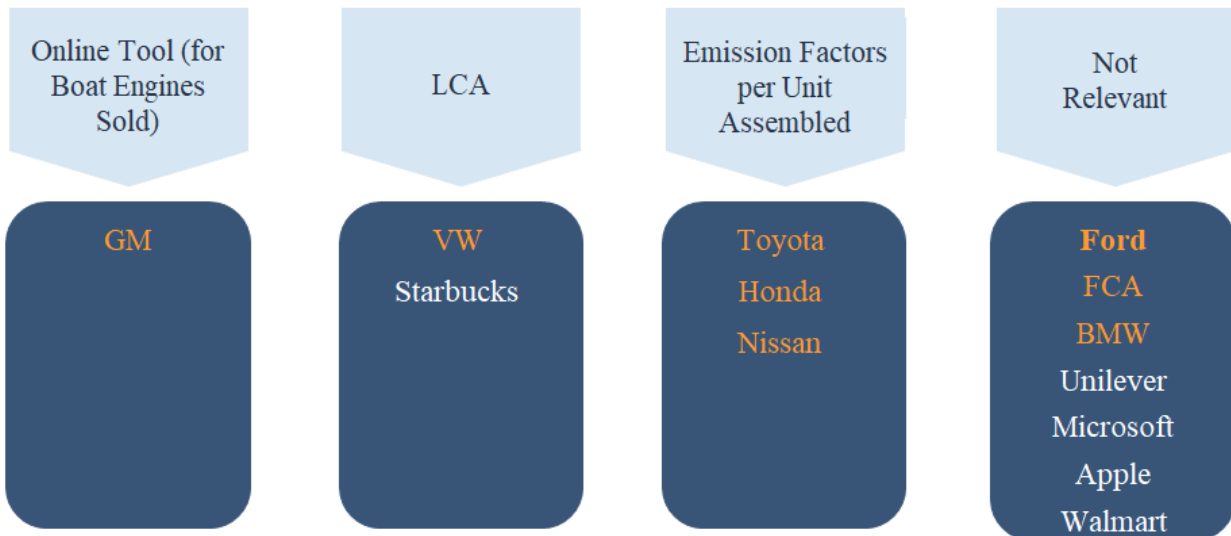
¹ CO₂e emissions per unit vehicle produced

² Uses real activity data

³ Distance based method for trucks

⁴ Covered in upstream T&D (both) and Franchises (BMW only)

10. Processing of Sold Products



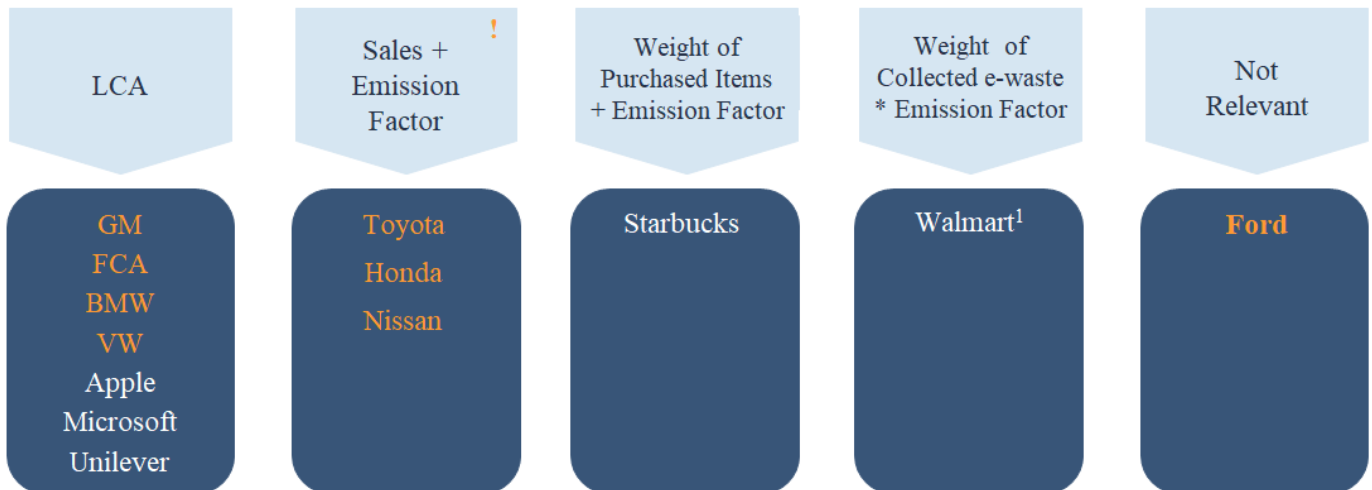
11. Use of Sold Products



¹ Use average regional mileage and life of product

² Walmart: Relevant, not yet calculated

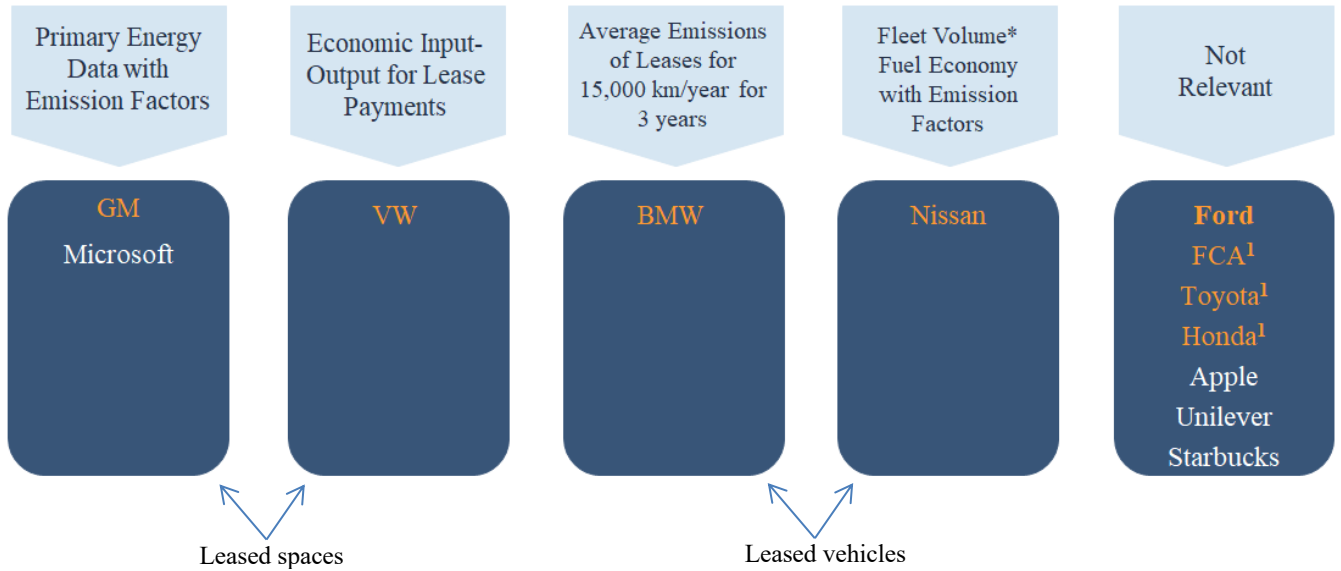
12. End-of-Life Treatment of Sold Products



¹ Only for South Africa, plan to expand scope over time

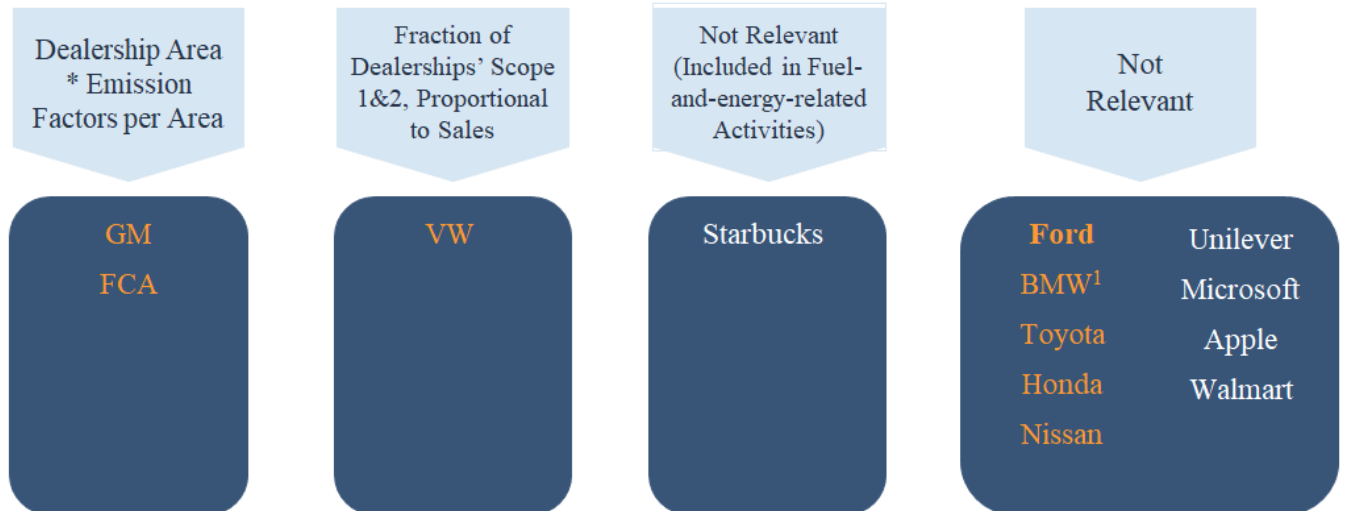
! GHG Protocol does not include methodology

13. Downstream Leased Assets



¹ Leased vehicles included in use of sold products

14. Franchises



¹ Rough estimate: Emissions per vehicle sold in dealership*global retail sales of non-owned dealerships

15. Investments

CDP-Sourced
Average
(CO₂e/\$)*
Investments

GM

Investees' Scope
1&2 Emissions
Proportional to
Shareholding
Ratio

Toyota
Honda

Not
Relevant

Ford	Unilever
FCA	Microsoft
BMW	Apple
VW	Walmart
Nissan	Starbucks

Appendix E: Ford's 2017 and 2018 CDP Reported Emissions

	2017 (mt CO₂e)	2018 (mt CO₂e)
Scope 1	1,304,409	1,391,127
Scope 2 (location-based)	3,486,767	3,482,444
Scope 3		
Purchased Goods and Services	13,133,594	42,178,358
Capital Goods	2,413	1,048,894
Fuel- and Energy-Related Activities	Not relevant	1,100,000
Upstream Transportation and Distribution	1,502,980	2,433,990
Waste Generated in Operations	22,295	127,979
Business Travel	57,192	55,976
Employee Commuting	651,750	104,840
Upstream Leased Assets	Not relevant	Not relevant
Downstream Transportation and Distribution	665,461	Not relevant
Processing of Sold Products	Not relevant	Not relevant
Use of Sold Products	131,000,000	161,400,000
End-of-Life Treatment of Sold Products	Not relevant	1,400,000
Downstream Leased Assets	Not relevant	Not relevant
Franchises	Not relevant	1,957,800
Investments	Not relevant	Not relevant
Total	151,826,861	216,681,408

Appendix F: Data Quality Indicators

Indicator	Description
Technological Representativeness	The degree to which the data set reflects the actual technology(ies)
Temporal Representativeness	The degree to which the data set reflects the actual time or age of the activity
Geographical Representativeness	The degree to which the data set reflects the actual geographic location of the activity
Completeness	The degree to which the data is statistically representative of the relevant activity
Reliability	The degree to which the sources, data collection methods and verification procedures used to obtain the data are dependable

Score	Technology	Time	Geography	Completeness	Reliability
Very Good	Data generated using the same technology	Data with less than 3 years of difference	Data from the same area	Data from all relevant sites over an adequate time period to even out normal fluctuations	Verified data based on measurements
Good	Data generated using a similar but different technology	Data with less than 6 years of difference	Data from a similar area	Data from more than 50% of sites for an adequate time period to even out normal fluctuations	Verified data partly based on assumptions or non-verified data based on measurements
Fair	Data generated using a different technology	Data with less than 10 years of difference	Data from a different area	Data from less than 50% of sites for an adequate time period to even out normal fluctuations or more than 50% of sites but for a shorter time period	Non-verified data partly based on assumptions, or a qualified estimate
Poor	Data where technology is unknown	Data with more than 10 years of difference or the age of the data are unknown	Data from an area that is unknown	Data from less than 50% of sites for shorter time period or representativeness is unknown	Non-qualified estimate

Appendix G: 2018 CDP Normalized Scope 3 Emissions for Auto Manufacturers

Emissions in mt CO₂e/unit sold	Ford	GM	FCA	Toyota	Honda*	Nissan	BMW	VW
Purchased Goods and Services	6.38	4.81	6.36	6.82	8.27	3.19	6.81	5.95
Capital Goods	0.16	0.48	0.28	0.43	0.24	0.21	Not relevant	1.28
Fuel- and Energy-Related Activities	0.17	0.04	0.03	0.11	0.09	0.07	Not relevant	0.13
Upstream Transportation and Distribution	0.37	0.32	0.18	0.09	0.56	0.13	0.60	0.41
Waste Generated in Operations	0.02	0.01	0.00	0.01	0.04	0.03	Not relevant	0.21
Business Travel	0.01	0.01	0.01	0.02	0.05	0.04	0.07	0.06
Employee Commuting	0.02	0.01	0.00	0.08	0.03	0.04	0.06	0.09
Upstream Leased Assets	Not relevant	0.00	0.00	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant
Downstream Transportation and Distribution	Not relevant	0.17	0.13	0.00	0.02	0.16	Not relevant	Not relevant
Processing of Sold Products	Not relevant	0.01	Not relevant	0.12	0.01	0.00	Not relevant	0.00
Use of Sold Products	24.43	23.01	18.78	36.67	49.61	33.79	21.06	23.15
End-of-life Treatment of Sold Products	0.21	0.37	0.19	0.41	0.76	0.08	0.50	0.10
Downstream Leased Assets	Not relevant	0.00	0.00	Not relevant	Not relevant	0.08	Not relevant	0.09
Franchises	0.30	0.01	0.03	Not relevant	Not relevant	Not relevant	Not relevant	0.14
Investments	Not relevant	0.01	Not relevant	0.02	0.02	Not relevant	Not relevant	Not relevant
Total	32.06	29.25	25.99	44.78	59.69	37.84	29.10	31.62

Units Sold	6,607,000	9,600,340	4,800,000	8,970,860	3,683,000	5,630,000	2,463,526	10,777,000
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* Automobiles correspond to 70% of the total Scope 3 emissions.