Analysis of Corporate Carbon Dioxide Footprints and Pledges

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A Major Qualifying Project
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Abstract

Carbon emissions are rapidly posing a more urgent threat to the planet. This is an issue that cannot be tackled by one group alone. Several companies across different industrial sectors are taking steps to practice corporate sustainability in regards to their direct and supply chain carbon emissions through reduction, offsets, and removal. This paper explores the steps taken by four role model companies, along with multiple progressive companies within four chosen sectors. The breakdown of their carbon footprints was analyzed and their different strategies were compared and contrasted. These companies have created individual goals for environmental sustainability; some have had success or show promise, prompting others to follow, while some are unrealistic or unsupported by true action.

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Authorship

Katherine Blumanthal contributed to the background (section 2.3) and the conclusions section, as well as all research and writing on Amazon and the agriculture sector. She also helped edit the entire report.

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1.0 Introduction

Carbon emissions are posing an increasingly great risk to the planet. Any company that provides a good or service inherently requires some form of physical input: manufacturing material, electricity, fuel for distribution, etc. A by-product of such input is commonly carbon dioxide, which gets trapped in the atmosphere, remaining trapped for up to a thousand years. Although carbon dioxide is a natural component of the Earth's atmosphere, the amount of it and the natural carbon cycle that removes it, has been affected by humans. The additional carbon dioxide can have several detrimental effects on the planet such as global warming and ocean acidification, which result in temperature changes, rising sea levels, and more hazardous weather phenomena. As the amount of carbon trapped in the atmosphere continues to rise, causing ever increasing damage, it has become imperative to reduce these emissions and remove them where possible. One group alone cannot bring about this change; the thousands of groups and companies that have been releasing this carbon have to contribute. This project serves to analyze various companies and their carbon footprint and mitigation methods in order to recommend ways that other companies can manage their own carbon emissions.

2.0 Background

2.1 Scopes Explanation

When describing the source of a company's carbon footprint, carbon emissions are categorized into three Scopes. Scope 1 emissions encompass a company's direct emissions (Greenhouse Gas Protocol, 2011). These directly produce carbon emissions, with an example being fuel combustion and consumption. Scope 2 emissions encompass a company's indirect emissions related to energy usage. This is most commonly through the use of electricity through steam generated from burning fossil fuels. When this energy is produced through the processing of fossil fuels, then the company is indirectly causing these carbon emissions. Scope 3 emissions encompass all of the indirect emissions that do not fall under Scope 2. This covers a broad range of possibilities, some of which may include employee travel, contracted waste treatment, product transportation, product distribution, purchased goods and services, end of life treatment for certain sold products, leased assets, etc. A visual of these three Scopes can be seen in Figure 1 below. Scope 1 and 2 emissions tend to be easier for a company to track and alter compared to Scope 3, since these emissions are more within the control of the specific company. A company's reliance on a particular type of emission varies as it depends on the type of service a company provides and the verticals most utilized by the company.

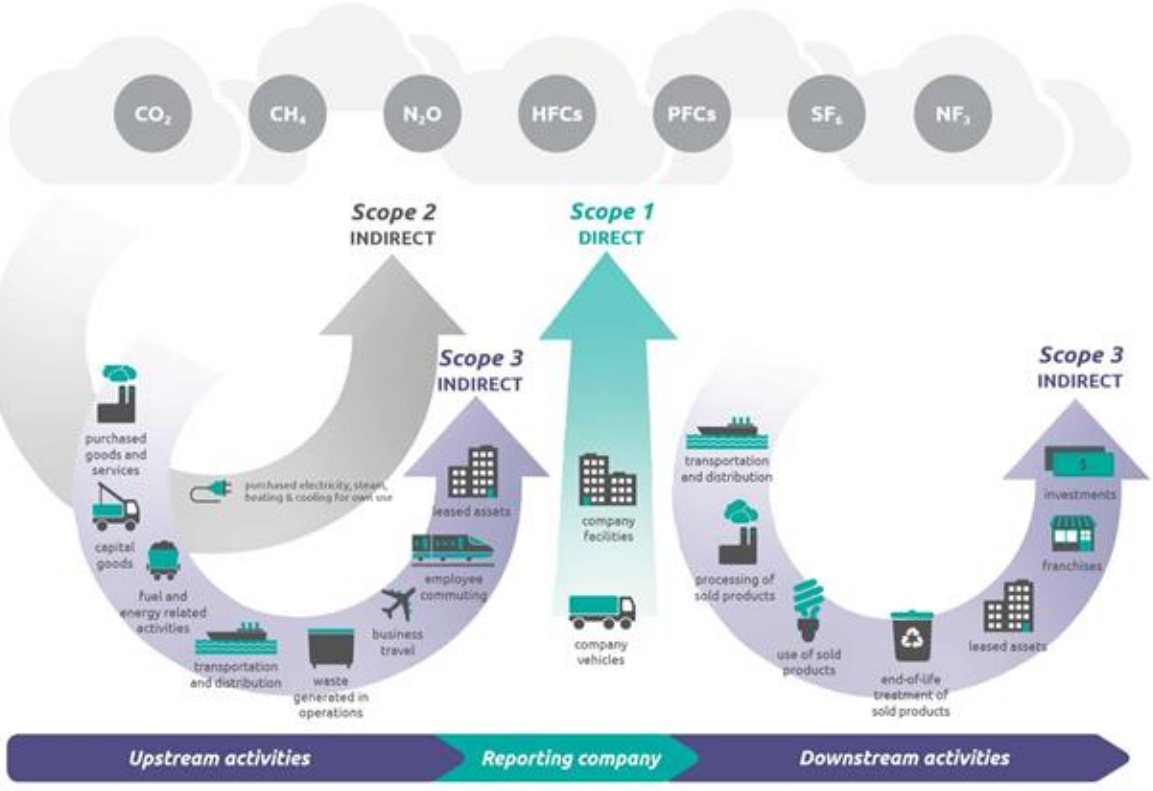

Figure 1: *The Three Scopes of Carbon Emissions (Greenhouse Gas Protocol, 2011)*

2.2 Types of Carbon Removal

There are two major types of carbon removal: nature-based and technological solutions like carbon capture and storage (CCS). They are both used to purchase carbon offset credits or to help a company become carbon negative.

Nature-based carbon removal is exemplified by projects like afforestation and reforestation, and restoring marine habitats, both of which reinforce the natural ways our Earth stores carbon. Regenerative organic agriculture is another example that involves a high level of land management to store carbon in the soil. These solutions tend to be easier and cheaper, but there is less permanence, which means that there is a higher likelihood that the carbon will be released back into the atmosphere.

Carbon capture and storage technology includes direct air capture (DAC), geological storage underground, and other technologies. It is categorized by having high permanence and additionality, which means that it is removing carbon that would otherwise always be in the atmosphere and the carbon is more likely to be permanently stored. Drawbacks of this solution are that it is more expensive and is in early stages of research.

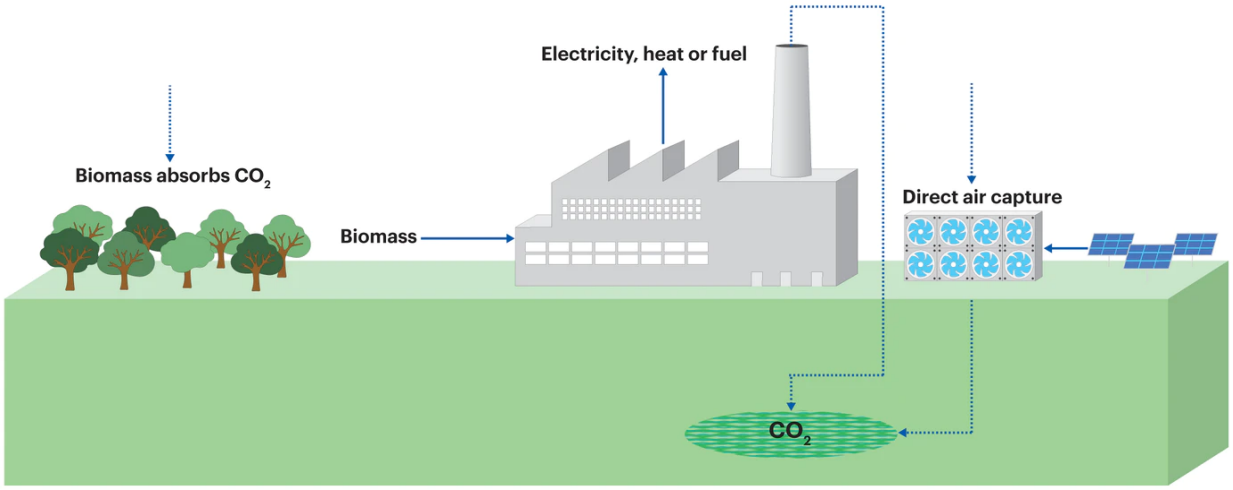

Figure 2: *Carbon Cycle of Bioenergy with Carbon Capture and Storage (IEA, 2020)*

2.3 Footprint Boundaries

The boundaries of a company footprint must be defined before any analysis can be conducted on the size of the footprint. For the purposes of this paper, we define the boundary primarily as the emissions that result on company owned land or emissions that are pertinent to producing the company's goods and services. The emissions included within the footprint are ones that the company can directly change: for example, by decreasing the amount of employee air travel or reducing the cardboard needed in their packaging. For our purposes, a company carbon footprint does not include legacy emissions, but rather it defines their current production of emissions. This definition includes Scope 1 and Scope 2 emissions and some Scope 3 emissions, namely those that

result from the transportation of the company's goods. For most companies, we have decided to exclude the footprint of building utilities such as the treatment of human wastewater, the treatment of clean water, and electricity. These are usually provided by individual cities and are thus out of the company's control. Some companies, such as Amazon, have more control over their purchased energy and thus include electricity within their footprint. This illustrates the complexity of defining any given company footprint. Careful consideration must be taken for each company and for what emissions are directly within their control and what emissions are not. The following list demonstrates other emission sources that we have excluded from a given company's footprint:

1. Off-site treatment and production of clean water, human wastewater, and building electricity;
2. Second degree transportation of products;
   (For example, the emissions that result when Company 1 brings their product to distributor Company 2 is included within the footprint of Company 1. Emissions that result from further transportation belong to Company 2.)
3. Building materials of repurposed buildings;
4. Non-company owned vehicles/aircrafts;
5. Use of sold products;
6. End-of-life product treatment;
7. Emissions produced by company investments.

The emissions we have included within a given footprint are summarized by the following list (all footprint emissions fall somewhere within these categories):

1. Raw product materials (chemicals, metals, paper, etc.);
2. Product packaging (plastic, paper, etc.);
3. Building materials for new company warehouses, office buildings, storefronts, and data centers (cement, steel);
4. Emissions released from company owned processes;
5. Emissions resulting from the production of purchased energy (electricity, steam, coal, etc.);
6. On or off-site treatment of solid waste or process wastewater;
7. Company owned vehicles/aircraft;
8. Aircraft/automobile/railway fuel used for the transportation of their products;
9. Aircraft/automobile/railway fuel used for the transportation of their employees;

Every company footprint analysis differs slightly. The purpose of our analysis is to show how a company's footprint is an example within their industry and how it can be applied to other companies within their industry. We will also illustrate how a company could decrease their footprint and offset their difficult-to-remove emissions.

In Section 4 we will describe the company footprints and decarbonization/offset pledges of four companies leading the way in sustainability: Amazon, Microsoft, Stripe, and Unilever. Some of these companies have clearly defined their footprint, while others require backend research and assumptions. After that in Section 5, we will analyze the footprints of several sample companies within the agriculture and food industry, the hospitality industry, the energy industry, and the retail industry. This analysis relies upon "verticals", as defined and explained in Section 2.4. This allows us to demonstrate the impact of reducing the emissions of an entire vertical (ex: automobile fuel) for an entire industry or even multiple industries. We will follow our company footprint analysis with strategies that we recommend for decarbonization and offsetting emissions.

2.4 Verticals

In order to properly analyze the carbon emissions produced by a company, we must break down a company's supply chain to its basic ingredients. These ingredients will be called verticals, and consist of basic, carbon-intensive materials such as steel, plastic, or fuel. Verticals slice through the carbon footprints of each company and provide a pillar of foundation for the product the company creates. Verticals start at the beginning of a manufacturing process and carry the product until the end of its life. The materials that are the foundation of the product are the materials that are disposed of at the end of the product's life. This section looks at five main materials that are used throughout many industries, and are a major cause of carbon emissions.

Fuel

Fuel is a broad term that applies to three main uses: aviation fuel, diesel, and gasoline. All three types of fuel are a derivative from petroleum, or crude oil, which is separated in an oil refinery by a distillation process. Transportation is often a major source of a company's carbon emissions, whether it is transportation of goods or people. The EPA reported that in 2018, 28% of total U.S. greenhouse gas emissions were from the transportation sector, which was the highest percentage of the five sectors listed (Environmental Protection Agency (EPA), 2021).

Fuel based carbon emissions are seen throughout all industries, and it is often one of their highest producing areas. Looking specifically at jet fuel, it is one of the most carbon-intensive areas of the aviation industry. A statistic from the EPA cites that 12% of transportation emissions are due to aircraft travel (Overton, 2019). Within that, 81% is due to global commercial travel and the other 19% is from air freight. Approximately 70% of the exhaust from airplanes is CO_2, with the rest consisting of water vapor and a small percentage being nitrous gasses. There are also carbon emissions released during the production of jet fuel, which is mainly comprised of kerosene.

The direct release of CO_2 into the atmosphere can be reduced in a couple of ways. Currently, more efficient planes are being manufactured and flight paths are being engineered to be more efficient (EDF, 2016). Alternative fuels such as biofuels are another option that is being explored, but has not been widely implemented yet. At the production level, there are many proposed technologies that reduce the amount of carbon released, including carbon capture at the source. One project

initiated by Climeworks is looking at the capture and use of CO_2 from the air to fuel jets. Their process turns the captured CO_2 into syngas using electrolyser cells from Sunfire GmbH, which is then turned into synthetic hydrocarbons which are used to create jet fuel (Climeworks, 2019).

Emissions related to gasoline and diesel are more widely understood by the general population since transportation is part of our everyday lives. The best known technological solutions to reducing vehicle emissions are more fuel efficient cars and hybrid and electric cars. Additionally, there are studies being done to look at the use of biofuels. One particular study conducted by Chang, Hwang, and Wu found that replacing a portion of the gasoline pumped into a vehicle with biofuels resulted in a 59.4% decrease in greenhouse gas emissions (Chang, Hwang, & Wu, 2017). However, the biggest issue they ran into is that the production of biofuels required a significant amount of energy, especially when using ethanol from corn (Chang, Hwang, & Wu, 2017).

Plastic

Plastic is everywhere: in short-term use like packaging and grocery bags, and in long-term use like electronics and toys. The total emissions due to plastic in 2015 were 1.8 billion metric tons of CO_2eq (University of California - Santa Barbara, 2019). Plastic is present in almost every industry, although it has the greatest impact in retail, manufacturing, and e-commerce. For a company like Amazon, plastic is a major vertical in its abundant use in packaging and products. A report written by Hamilton and Feit from the Center for International Environmental Law (CIEL) found that 40% of plastic produced globally is used for packaging (Hamilton & Feit, 2019).

Plastics are made by processing natural gas or oil to produce alkenes and aromatic structures, which are turned into polymers that make up the plastic materials. According to the World Economic Forum, 4-8% of the world's oil consumption is due to the production of plastics (Hamilton & Feit, 2019). The entire manufacturing process of plastics has carbon emissions, starting with the extraction and transportation of raw materials. The CIEL report estimated that 12.5-13.5 million metric tons of CO_2eq are emitted per year by the U.S. for the extraction and transportation of natural gas for the purpose of manufacturing plastic (Hamilton & Feit, 2019). For the production and refining of oil, they estimate 108 million metric tons of CO_2eq are emitted per year by the U.S. (Hamilton & Feit, 2019). Dormer et al. conducted an analysis of the carbon footprint of a plastic tray used in food manufacturing and found that 45% of emissions are related to the extraction and processing of raw materials, with 38% due to manufacturing and the remaining 17% coming from secondary packaging, transport, and end-of-life stages (Dormer et al., 2013).

Solutions for reducing the emissions related to plastic production range from reducing the demand for plastic to developing technologies that change the manufacturing process. While reducing the demand for plastic would result in a direct reduction of emissions, it is not probable in our consumerist society. A seemingly simple solution would be to recycle the plastics, especially since a 2018 statistic calculated by UC Santa Barbara industrial ecologist Roland Geyer showed that

globally, 90.5% of plastics are not recycled (UC-Santa Barbara, 2019). A study conducted by Zheng and Suh recommends a combination of renewable energy, recycling, and a reduction in demand to keep carbon emissions low, but those combined efforts don't fix the problem entirely (Zheng & Suh, 2019). Both the study by Zheng and Suh and the CIEL report suggest the use of bio-based feedstocks to reduce emissions in the refining stage. However, a zero-carbon energy source would only reduce the total manufacturing emissions by 50%, so this solution in conjunction with the others mentioned would start to display a significant decrease in carbon emissions from the production of plastic (Hamilton & Feit, 2019).

The study done by Dormer et al. found that reducing the weight of a plastic tray reduced the carbon emissions by an almost proportional amount. Additionally, they discovered that since most emissions were due to the processing of raw materials and manufacturing, optimizing transport and recycling had a more minor effect on the decrease in carbon emissions. Instead, they recommended optimizing extrusion and thermoforming process speeds to reduce energy use. Finally, they found that using a higher percentage of recycled material during manufacturing showed a significant decrease in the carbon footprint of the product (Dormer et al., 2013).

Steel

Steel is a material used in industries that require a lot of building products. It is a major vertical among e-commerce and technology companies that require many data-centers to be built. It is also present with companies that need to build many warehouses and manufacturing facilities. As of a report published in 2020, the iron and steel industry produces 7% of the world's greenhouse gas emissions (Bhaskar et al., 2020). An iron and steel report produced by the International Energy Agency (IEA) displayed that increases in energy efficiency have reduced current emissions from the industry back to what they were a decade ago, but now that the easier fixes have been used it will take more work to continue to keep the emissions numbers constant or even decreasing (Levi et al. , 2020a). These reductions are also due to an increase in use of scraps, although this is not a solution that is used to its full potential. To increase the use of scraps, more effort must be made to collect and recycle, especially with steel at the end of a product's life.

The carbon intensity of steel is high due to the emissions released during the manufacturing process. Steel is created from iron oxides using one of two methods: a blast furnace or an Electric Arc Furnace (EAF) (World Coal Association, 2020). A key ingredient in using a blast furnace is coke, a hard black rock that consists of almost entirely carbon that is created through a process of heating coal and burning off all the volatile matter (WCA, 2020). A blast furnace combines iron ore, coke, and limestone to eventually make steel. EAFs on the other hand don't need raw materials and instead use existing steel and some supplements heated with an electric charge between two electrodes (WCA, 2020). Both processes require a lot of energy to heat the materials at many different stages, which is a large source of the carbon emissions. The IEA report cited that 75% of energy is sourced from coal in the steel making industry (Levi et al., 2020a). Additionally, a lot of the processes emit greenhouse gasses as a product of the reactions that are occurring.

Some solutions that have been proposed for the reduction of carbon emissions in the manufacturing of steel are related to a change in energy sources and improving the technology of the manufacturing process. One that has already been implemented commercially is a carbon capture process in Au Dhabi called the Al Reyadah project (Carbon Sequestration Leadership Forum, 2017). It's a carbon capture, use, and storage (CCUS) project organized by Abu Dhabi National Oil Company (ADNOC), Masdar, and the Emirates Steel Industries (ESI) that captures the CO_2 from the process exhaust and injects it into oil fields. The project has been successful since its launch in 2012 and is able to capture and store up to 800,000 tons of carbon emissions per year (CSLForum, 2017). Another method that is being developed is replacing the use of coke in a blast furnace with hydrogen produced from water hydrolysis (Bhaskar et al., 2020). This coupled with an EAF would provide a carbon free alternative to using a blast furnace. A report written by Bhaskar, Assadi, and Somehsaraei of the University of Stavanger in Norway found that this process could reduce carbon emissions by more than 35% (Bhaskar et al., 2020). Other processes that are being researched are the HIsarna process that reduces the use of coal during the smelting process, the use of low-temperature aqueous alkaline electrolysis, or electrowinning, and the use of iron ore pyroelectrolysis (Levi et al., 2020a; WCA, 2020).

Cement

Concrete is a material used in the construction of large buildings and structures. Similar to steel, this is a major vertical in the e-commerce and technology industries, as well as manufacturing and retail. The components of concrete are water, aggregates, and cement, which is the carbon-heavy component. The cement industry alone is responsible for 5-7% of global man-made carbon emissions (Maddalena et al., 2018; Barcelo et al., 2014). Cement is manufactured from limestone, clay, and gypsum, which are all abundant, naturally occurring materials. The process starts by grinding down the raw materials into a fine powder, then putting them in a kiln for pyroprocessing (Leetham, 2015). The chemical reactions that happen at the high temperatures produce a product called clinker (Leetham, 2015). This is also the step of the process that produces the most carbon emissions, both from the energy required to heat the kiln and as a by-product of the calcination process. A report by Maddalena, Roberts, and Hamilton cited that pyroprocessing produces 85% of the carbon emissions in the whole process of creating cement, where calcination produces 50% of the emissions and the remaining 35% are from fuel and energy consumption (Maddalena et al., 2018). The final step is to grind the clinker down into a fine powder and mix it with gypsum to produce cement (Leetham, 2015).

Reducing the carbon footprint of concrete can start by using renewable energy sources for the manufacturing processes of cement. Additional technologies exist to reduce the amount of carbon emitted during the process of creating clinker. One study looked into the feasibility of using low-carbon materials that act similar to cement, like metakaolin, silica fume, nano-silica, and calcium hydroxide (Maddalena et al., 2018). They found that the use of these materials reduced the amount of carbon emissions by 23-55% compared to Portland cement, the most common type of cement (Maddalena et al., 2018). Another study explored the use of clinkers that require less limestone,

which would reduce the amount of CO_2 produced by 20-30% (Barcelo et al., 2014). The material used instead is referred to as belite-calcium sulfoaluminate-ferrite, or BCSAF, which requires less limestone and less energy to power the kiln (Barcelo et al., 2014). When substituted for current clinker, it was shown to have similar properties to Portland cement while producing less carbon emissions (Barcelo et al., 2014).

While those technologies reduce emissions and are certainly necessary to improve the carbon footprint of cement, the remaining emissions should still be collected and stored to produce a carbon free process. An example already in the works is a collaboration between Svante and the construction company Lafarge at multiple locations to capture and use the carbon emissions produced by the cement manufacturing process. At a location in British Columbia, Canada, the carbon capture technology developed by Svante is being used to contain, capture, and reuse the CO_2 emissions for onsite conversion technologies (Svante, 2019). Another location in Colorado is also using Svante's capture technology, but instead the carbon is being given to a subsidiary of Occidental to be sequestered into the ground (LafargeHolcim, 2019).

Pulp and Paper

With the recent digitization of newspaper, books, and print, some would expect the pulp and paper sector to experience a decrease in demand, but it has actually increased with the need for more packaging and sanitary paper use. Between the years 2010 and 2017 the demand for printed words decreased by 2.4% annually but the demand for packaging and sanitary paper increased by 2.3% annually (Levi et al., 2020b). Overall, the pulp and paper industry accounts for 2% of global carbon dioxide emissions (Kong et al., 2016). The industries that see pulp and paper as a vertical are mainly companies that use a lot of packaging such as retail and manufacturing. Emissions within the sector come from energy use and products produced from lime kilns, wastewater, and landfills (Kong et al., 2016).

To reduce the emissions of the pulp and paper sector there are a couple of strategies. Simple ones that are already being used today include increasing the use of recycled material and using renewable energy sources. Another solution that requires more research and development than the first two is increasing energy efficiency. A paper by Kong, Hasanbeigi, and Price reviewed 25 proposed energy-efficiency technologies for the pulp and paper sector, in which they concluded that the best technologies cut water and energy consumption, as well as increasing drying efficiency (Kong et al., 2016). Specifically looking at increasing drying efficiency, the use of gas-fired dryers would reduce emissions compared to steam-heated cylinders with the availability of natural gas (Kong et al., 2016).

Another option to reduce emissions would be to introduce the recovery of biomass. Biomass loss is found at three points in the paper-making process: pre-treatment of organic solid waste, black liquor (a by-product of extracting the cellulose fibers from the wood), and wastewater treatment

(Wang et al., 2016). Recovering biomass would allow it to be recycled and used as another form of energy, decreasing the overall carbon footprint of the paper-making process.

2.5 Differences Between Emission Types

To better understand which industries have the greatest impact in contributing to climate change, it is vital to understand what the various GHG emissions they create are, and how they create them. In understanding this, it can be made clear how difficult it is to mitigate and avoid emissions from different sources. The GHGs that are most prevalent are carbon dioxide, methane, nitrous oxide, and various fluorinated gases. The relative amounts of these GHGs released in the US are shown in Figure 3.

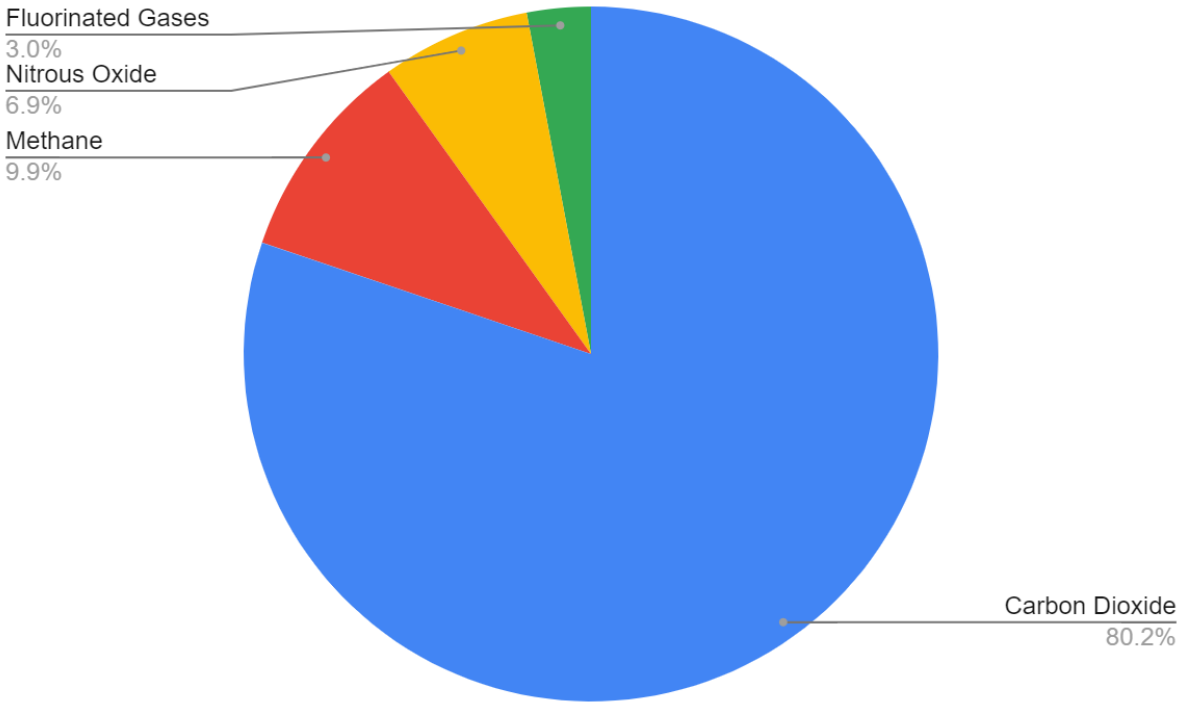

Figure 3. *2018 data for proportions of greenhouse gases emitted in the United States. Total emissions were 6,677 million metric tons of CO_2 equivalent (EPA, 2021).*

Each of the GHGs has a different impact on climate change measured by their potency to trap heat compared to the most prevalent GHG, CO_2. The species can persist for vastly different amounts of time in the atmosphere. CO_2, for example, can last between 300 to 1,000 years in the atmosphere. Methane comparatively lasts for around 10 years in the atmosphere. CO_2 equivalents are based around species ability to contribute to global warming over 100 years. Equivalencies for key GHGs are shown in Table 1. CO_2 equivalencies are compared to CO_2's global warming potential (GWP) at 100 years.

Table 1. *Global warming potential (GWP) of greatest contributors to climate change in the US. All are compared relative to CO_2, which has a GWP of 1 (IPCC, 2007).*

Species Name	Lifetime in atmosphere (years)	Global Warming Potential for 20-years	Global Warming Potential for 100-years
Carbon dioxide	300-1,000	1	1
Methane	12	72	25
Nitrous oxide	114	289	298
Fluorinated Compounds	1-50,000	207-16,000	59-17,700

As is made clear by Table 1 there are huge differences in the potency of different GHGs. This is vital to companies looking to reduce their emissions. As dictated by the second law of thermodynamics the amount of work required to separate gases increases exponentially as the solute gas concentration decreases. This trend is demonstrated for CO_2 in Figure 4. It is for this reason that it is important when a company is planning to reduce their emissions that the amounts of different GHGs are emitted and what processes they come from. This way the emissions that are easiest and have the greatest GWP can be removed first. If removing one kilogram of methane from a process is easier than removing one kilogram of CO_2, it is much better for the focus of the firm to deal with the methane, for example. It is also imperative to note that the nature of process creating emissions will determine how difficult it is to abate or mitigate those emissions.

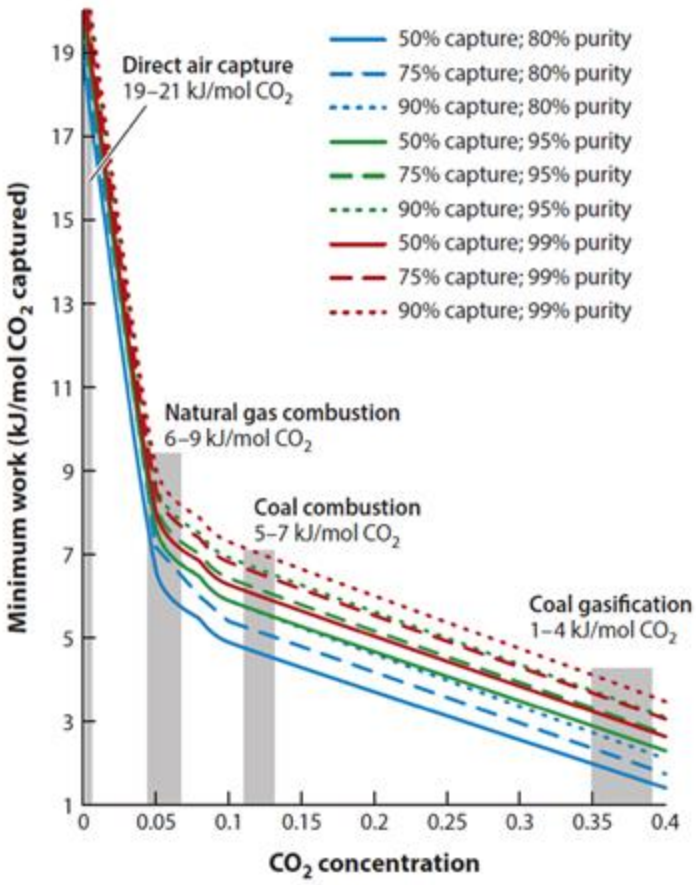

Figure 4. *Minimum thermodynamic work versus CO_2 concentration demonstrating the difficulty with separating dilute species from solution.*

Cement production is one such process that has emissions that are very difficult to avoid. In 2015 worldwide cement production accounted for around 2.8 billion tonnes of CO_2 (Carbon Brief, 2018). About half of those emissions come from the chemical decomposition of calcium carbonate, $CaCO_3$ into calcium oxide to produce lime, CaO (Rodgers, 2018). The chemical equation for this reaction is as follows:

$$CaCO_3 + heat \rightarrow CaO + CO_2$$

Because of the carbon necessary there are only a few options regarding cement emissions. Cement must either be entire phased out of use and replace with an option that does create emissions. This is unlikely as cement is practically ubiquitous worldwide and offers highly useful mechanical properties at relatively low cost. This means the cement's footprint must be reduced in other ways. This can be achieved by mixing other substances in with cement that do not compromise its integrity but mean less cement must be used. The CO_2 can be scrubbed as production happens so less reaches the atmosphere. This only offer some help, but cannot possibly counter all the emissions. This means offsets must be used to some extent to clean up the remaining emissions other reduction techniques cannot cover.

3.0 Methods

3.1 Four Model Selection Process

Our team started with a list of over 100 company pledges that had been made in the past five years. Each team member started by looking at about 10 company pledges, identifying the companies that had high reaching climate goals and already showed some progress to achieving them. We were looking for role model companies that could be used as an example of great corporate sustainability. Some of the specific criteria we were looking for was increased media outreach and attention on their goals, large companies with many emission sources and potentials for improvement, and companies that showed tangible steps they have taken to back up their projected achievements. With guidance from our advisor and a graduate student, we knew role model companies would approach corporate sustainability with a general mindset of first reducing easy to remove emissions, showing effort to cut down in all areas of their footprint, and finally looking at purchasing carbon offsets to offset the rest of their emissions. As a final consideration, we also tried to pick four companies that provided a wide scope of products and services while having emissions that are relatable to many other companies.

3.2 Four Model Analysis Criteria

Within the large four companies investigated, data of several general categories was investigated. The first broad category was quantitative data on the actual carbon footprints of the companies. This could be sourced directly from information made freely available from the company, or in other cases, from external analysis performed by different groups. Wherever possible, the granular details of the footprint could be broken down was also researched. This primarily meant further categorizing the emissions into source type as well as which Scope. For example, perhaps it is found that a company had 1,000 gigatonnes of emissions annually. This might be broken down into 30% from manufacturing, then 50% of that is from electricity and the rest from material sourcing. These data would be then classified into either Scope 1, 2, or 3 emissions.

The next primary kind of data sought after were the plans and actions taken by the companies to reduce their footprints. This included the proposal of the given company for reductions. This would broadly take the form of some percent reductions to their footprint by some year. The companies' plans offered varying levels of detail, the same kind of quantitative information regarding emissions categories and scope were examined. In addition to the proposals, any documentation of the actual strategies that the companies have implemented were recorded. Where possible, quantitative data about the effective reduction of these strategies were documented. In particular details regarding companies CDR (Carbon Dioxide Removal) methods were sought after. One expert opinion was found regarding this matter. An interview was performed with Ryan Orbuch, a Stripe representative who spoke on Stripe's CDR efforts.

Our team also used a set of criteria originally created by Dr. Pete Psarras (Carbon Direct, 2020). It is a list of five quality carbon dioxide removal characteristics, which are additionality, permanence, leakage, carbon accounting method, and do no harm. Additionality is the amount a

carbon removal project removes from the atmosphere that is additional to what is already being removed. For example, protecting a forest has low additionality because the forest already exists and is actively removing carbon. DAC has high additionality because it is directly removing carbon from the atmosphere that would otherwise always be there. Permanence refers to the amount of time carbon is likely to stay in the source. Trees have low permanence because their natural lifespan isn't infinite, and they can be easily destroyed by a forest fire or due to logging. In comparison, carbon storage in rocks has high permanence because it is a more permanent storage option. Leakage can be both physical and socioeconomic. Physical leakage occurs when carbon is re-released into the atmosphere after it is stored. Socioeconomic leakage occurs when emissions are displaced due to a CDR project which negatively affects another location. A carbon accounting method is important to know the entire effect of a project and to ensure any blind spots are addressed. Finally, it is always important to make sure that a CDR project does no harm to the surrounding natural, social, or economic environments.

3.3 Sector & Companies Selection Process

Several industries were considered including agriculture, automotive, aviation, construction, ecommerce, financial, health and wellness, hospitality, manufacturing, oil and gas, retail, and technology. Between these, each project member chose an industry of interest to focus on. At the start of the project, we chose individual companies from each sector that had publicly pledged to cut all, or a significant portion, of their carbon footprint. Further surface research was conducted on many of these companies in order to understand the details of their pledges. It was also important to find if these companies readily provided information about their supply chain and their reduction plans. Companies with seemingly obtainable goals, detailed plans, and available information were considered for a deep dive analysis.

3.4 Sector & Companies Analysis Criteria

When it came time to analyze our findings for each industry, there were a couple key points we were looking to highlight. First was to deconstruct the general carbon footprint for each industry. This included looking at where their most carbon-intensive steps were in the supply chain and identifying what verticals were at the root of those emissions. This information was found in documents that each company publicly made available. Often these documents were annual sustainability reports, press releases, public pledges, and any information found on their website. Identifying these verticals provided insight on what companies within the sector should focus on to best reduce their carbon footprint. We also looked to quantify emissions to provide an easy way of comparing across sectors later. This involved breaking down each company's emissions

into hard to reduce emissions, their highest emission sources, totals for Scope 1, 2, and 3, as well as overall totals. Any totals are measured in units of metric tons of CO_2 equivalents (tCO_2e), which is a standard unit of comparing emissions of all greenhouse gases. This allowed us to compare companies within each sector, as well as across different sectors, and help identify what is causing the most emissions and where they are coming from.

One important concept we wanted to identify is the difference between carbon reductions and carbon offsets. Knowing which sectors focused on each type of carbon removal provided another basis for comparison and analysis. The main focus of our analysis was to look at comparing the companies' approaches to carbon reduction and removal, so other sustainability plans such as water or energy efficiency plans were read about but not commented on in this project. Keeping these criteria in mind, we were able to separately conduct an analysis about our industry of choice with underlying trends that were later identified when we put the research together.

4.0 Four Model Companies

Based on the criteria highlighted in our Methods section, our team found that Stripe, Microsoft, Amazon, and Unilever were role model companies. The following sections will look to break down the pledges and strategies of each company, any progress they have made, and then analyze those findings based on the criteria outlined in section 3.2.

4.1 Stripe Findings

Stripe is an e-commerce company that provides payment processing software to online retail companies. Because their product is a virtual service, Stripe has relatively low emissions compared to companies in other industries. The main source of their emissions are due to building and supplying energy to their data centers, along with any travel related emissions from their employees. Their main verticals are fuel, steel, and cement. First announced in 2018, their low emissions have allowed Stripe to focus more on purchasing carbon offsets. Since then, they have developed an application system for projects and companies to apply to be one of their purchases, along with a program where customers can direct a portion of their revenue to invest in these companies as well.

Announced in August 2019, Stripe's "Negative Emissions Commitment" pledges at least $1M per year to pay, at any price, for the direct removal of carbon dioxide from the atmosphere and its sequestration in secure long-term storage (Anderson, 2019). Although they say they'll "pay any available price", they expect it to be about $100+ per ton of CO_2 (Anderson, 2019). Stripe sees an opportunity to create a demand for carbon removal, which is an area of climate change that hasn't received much financial support yet. As explained by a member of their climate team, Ryan Orbuch, Stripe has an in-house approval program where they ask for companies and projects to submit proposals for Stripe to invest in (Orbuch, personal communication, 2021). These proposals are considered based on a set of criteria, with additional input from carbon-removal experts. In 2020, four companies were chosen and each received approximately a quarter of a million dollars. All four projects focus on the capture and/or long-term storage of carbon. With advancements being made to this commitment, it is expected that Stripe will announce it's next round of carbon removal purchases during the summer of 2021.

The companies Stripe invested in in 2020 are Climeworks, Project Vesta, CarbonCure, and Charm Industrial. Climeworks is a capture and storage company based in Zurich, Switzerland. They capture CO_2 directly from the air and, partnered with another company called CarbFix, store it in basaltic rock off the coast of Iceland (Orbuch, 2020b). They are also developing a new, larger carbon removal facility in Iceland (Stripe, 2020). Project Vesta is conducting a mineralization project in San Francisco where they capture CO_2 from the ocean with olivine (a rock) and store it as limestone in the bottom of the ocean (Orbuch, 2020b). CarbonCure is a utilization company based in Halifax, Canada. They take CO_2 from industrial emissions and store it into concrete (Orbuch, 2020b). Finally, Charm Industrial is another storage only company based in San

Francisco. They create bio-oil which contains CO_2 initially captured by plants, which is then injected into geologic storage (Orbuch, 2020b).

In 2020, Stripe also announced the world's first large-scale carbon offsets program, Stripe Climate, which allows their users to direct a portion of their revenue to invest in the offset projects of Stripe's choosing (Stripe, 2020). As of February 2021, Stripe Climate is now available globally. Stripe's users range from Fortune 500 companies to start-ups, so they found a way to facilitate companies of any size contribution to carbon removal. Stripe sees this program as a way to help create a demand for carbon removal technology.

4.2 Stripe Analysis

When a company starts to consider purchasing carbon offsets there are some quality characteristics that should be considered. Stripe touches upon some of these characteristics directly in their climate posts, while others are implied. In their announcement of their first carbon removal purchases, they list their target criteria as sequestration beyond the biosphere, volume, cost, permanence, verifiability, quality and safety, and net-negative lifecycle (Orbuch, 2020b). They also have a list of Legacy Purchase Criteria that they looked for when they chose which companies to invest in in 2020. The figure below details the criteria they outlined (Orbuch, 2020a). Some of these already overlap with the quality characteristics.

Legacy 2020 Purchase Criteria

	Criteria *We aim to purchase from projects that...*	Rationale
1	Have volume available for purchase in 2020	We aim to **fulfill our commitment** to buy $1M of net-negative removed carbon in 2020.
2	Have a carbon negative complete lifecycle (including energy use, etc)	
3	Provide durable, long-term storage of carbon	We aim to purchase **high quality** sequestered tons. These criteria all aim to assess different aspects of quality.
4	Use scientifically rigorous and transparent methods to verify that they're storing the carbon that they claim, over the period of time they claim to	
5	Are globally responsible, considering possible risks and negative externalities	
6	Have the potential to scale to high volume and low cost (subject to the above constraints)	We know that today, price may be high and volume may be low. That's fine. Instead, we care that a given solution has a **path to low cost and high volume**, and thus a massive potential impact on the climate.

Figure 5: *Stripe Legacy Purchase Emissions for 2020 (Orbuch, 2020a)*

The quality characteristics the four projects seem to focus on the most is permanence (aka durability). Stripe specifically chose to avoid nature-based removal purchases because they have a low level of permanence. Instead, they prioritized investing in "long-term storage" projects, which is defined by Stripe as greater than 1,000 years (Orbuch, 2020b). Climeworks and Project Vesta both store carbon in rocks, while CarbonCure stores it in concrete. Charm Industrial stores the carbon in the form of bio-oil which is then injected into the ground. Stripe also specifically explains permanence on their climate posts and highlights the importance of prioritizing it with carbon removal projects. Stripe's investments all meet its own criteria on permanence, which is a crucial element of CDR.

All the companies Stripe chose to invest in have additionality because they are projects that remove carbon that otherwise would always be in the atmosphere. Nature-based solutions, specifically forest credits, have a low percentage of additionality. There is research by Barbara Hyatt that says that 80% don't have additionality (Orbuch, personal communication, 2021). A project without additionality would take credit for the removal of carbon that would have occurred regardless, like saving an existing forest that is already removing carbon. Direct carbon removal, in the case of Climeworks and Project Vesta, have an immediate effect on the amount of carbon in the atmosphere that would otherwise be there if the projects didn't exist.

Leakage is not directly discussed in Stripe's blog posts, but the projects they choose have a lower chance of leakage because of the nature of their storage. Climeworks, Project Vesta, and Charm Industrial are storing their carbon underground or at the bottom of the ocean where there is less influence by humans. Increasing the changes of the carbon staying undisturbed decreases the likelihood of leakage. Stripe also has a net negative lifecycle criteria, where they highlight the importance of a project reducing more atmospheric CO_2 than they produce (Orbuch, 2020b).

Stripe has an expectation that the projects they invest in will properly account for the carbon they are producing in the process of sequestration and storage. They address this in their criteria that the companies must "use scientifically rigorous and transparent methods to verify that they're storing the carbon they claim, over the time period they claim to," (Orbuch, 2020a). Stripe's use of scientific experts to choose the companies they want to invest in shows their commitment to achieving this criteria. As listed on their website, the expert advisors Stripe consulted in 2020 are professors and scientists that specialize in DAC, ecosystem ecology, carbon mineralization, soil carbon, and forestry (Stripe, n.d.). The advice of these experts was crucial in making credible decisions about validity (Orbuch, personal communication, 2021).

The last criteria to "do no harm" is addressed in Stripe's target criteria "Quality and Safety." They describe this as a company that "is globally responsible, considering possible risks and negative externalities" (Orbuch, 2020b). Of the projects they chose to invest in, the majority are in their testing phase so any concerns would hopefully be addressed during this stage. For example, in their explanation of Project Vesta, it is included that "questions remain about safety and viability: to validate coastal enhanced weathering, more lab experiments and pilot beach projects must be performed" (Orbuch, 2020b). This shows that even if these problems haven't been addressed yet, it is on their radar and they consider it important to note.

Overall, Stripe is an exemplary company for purchasing carbon offsets. They acknowledge that the process they are following, with asking for applications and reviewing them individually with a group of experts, is more in depth than most companies can attribute time to (Orbuch, personal communication, 2021). Stripe sees an opportunity to do this leg work and set an example for other companies to follow. They even took it a step further by instituting their Stripe Climate program, where all the company has to do is decide to invest. Not only are they doing the hard work up front, Stripe has clearly considered the important aspects to carbon removal purchases and acknowledge the necessity to do it right the first time.

4.3 Microsoft Findings

Microsoft is a technology company that develops software, computers, and other electronics. In 2012, the company declared itself carbon neutral (Microsoft, 2021). Since then, the company has pledged to be carbon negative by 2030 and to remove from the environment more carbon than they had emitted since their founding by 2050. Some of the details of their planning can be seen in Figure 6 below.

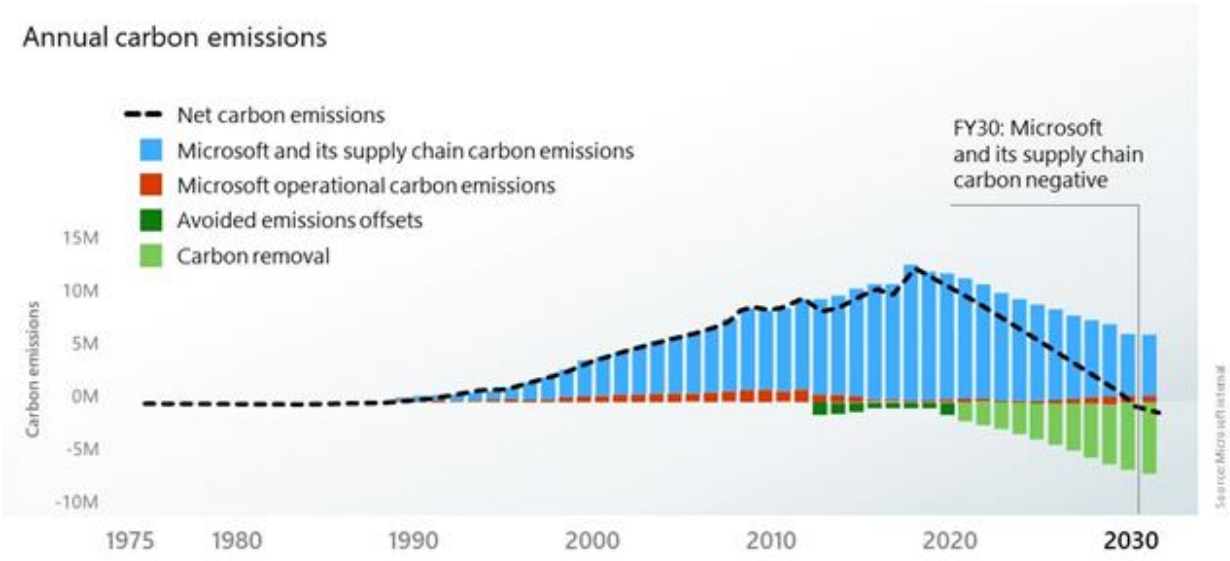

Figure 6: *Microsoft's Pathway to Carbon Negative by 2030 (Smith, 2020)*

Microsoft's overall emissions have been increasing over the past several decades, peaking in 2018. This behavior is expected as the company itself has also expanded over the past several decades. Microsoft's 2012 carbon neutrality was achieved primarily through the investment in offsets. Following Microsoft's carbon negative plan, they see themselves achieving this through emission reduction, some offset, and primarily carbon removal in the coming years.

In order to achieve this, their goals are to reduce Scope 1 and 2 emissions to near zero in this decade and their Scope 3 emissions by more than half by 2030 (Smith, 2020). This plan is then combined with their offset and removal efforts. Their emissions can also be broken down by scope as seen in Figure 7.

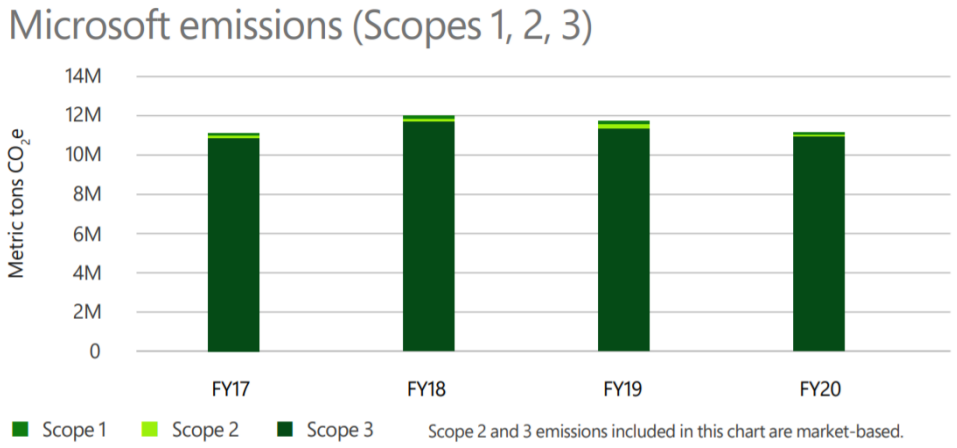

Figure 7: *Microsoft Emission Breakdown (Microsoft, 2021)*

As can be seen, the reduction of the Scope 3 emissions is the most crucial as they are the greatest source of Microsoft's carbon footprint. The sources of these emissions can also be broken down

and it can be seen that the greatest sources of these emissions are the use of their sold products, purchased goods and services, and capital goods (Figure 8) (Microsoft, 2020).

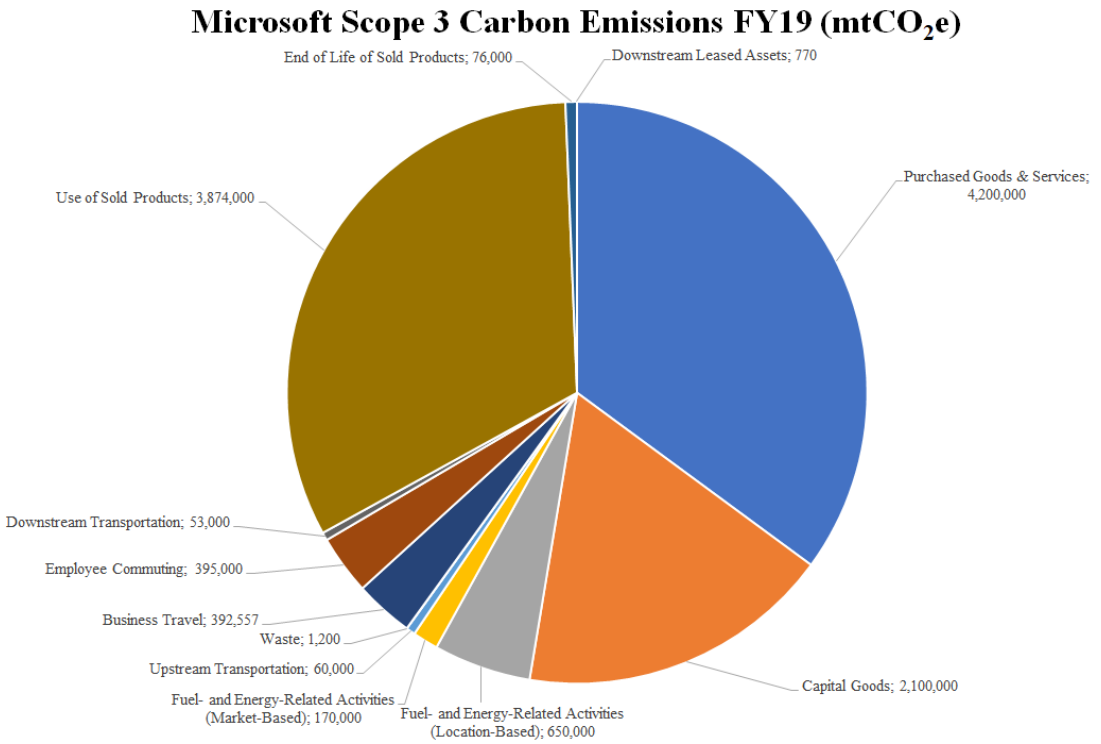

Figure 8: *Microsoft Scope 3 Emissions Breakdown in 2019*

These are many ways they have gone about reducing emissions including using low carbon fuel sources including hydrogen, energy storage, plans to eliminate dependency on diesel fuel by 2030, having an electric vehicle fleet of 1800 vehicles by 2030, implementing an internal carbon fee for Scope 3 emissions, and reducing travel (Joppa, 2020; Microsoft, 2021). Since these emissions cannot be reduced completely, offsets and carbon removal are used. Some of their removal and offsets plans include obtaining renewable energy power purchase agreements for 100% of the day-to-day power of data centers by 2025, establishing a partnership with Sol Systems, a renewable energy developer, for 500 megawatts of renewable energy, and reforestation (Joppa, 2020; Microsoft, 2021). Microsoft has also made several investments with carbon removal, offset, and research companies. Their most recent progress can be found in their 2020 environmental report which shows a 586,683 metric ton carbon dioxide reduction for the year (Microsoft, 2021). Also in the 2020 report, Microsoft reported that they had secured projects for 2021 for the removal of 1.3 million metric tons of carbon, which exceeded their goal of 1 million.

4.4 Microsoft Analysis

As previously stated, Microsoft has planned for carbon removal to be their greatest tool towards their goal of becoming carbon negative by 2030 and their plans show that they are prepared to start that pathway this year. Microsoft has stated that its primary focus is towards carbon removal

technological development and investments in new innovations. They have also expressed an interest in carbon monitoring and modeling. Towards this, they have arranged a Climate Innovation Fund of $1 billion (Microsoft, 2021). Much of this is put towards carbon innovative companies such as Aclima, Climeworks, Energy Impact Partners (EIP), and CarbonCure. Climeworks, a carbon capture technology company, and CarbonCure, a low greenhouse gas emission concrete technology company, were both also previously mentioned as investments by Stripe. Aclima is a research company that maps air quality on a hyperlocal scale. Their platform measures both air pollutants and greenhouse gases. Their research is thus beneficial towards Microsoft's goal of monitoring emissions. Microsoft has invested $50 million of its climate fund into EIP, a coalition working towards promoting growth in the studies of sustainable energy, energy usage optimization, and the transportation sector (Microsoft, 2021; Business Wire, 2020c). The EIP is an investor in new technology, much like Microsoft is working toward, and both have the goal of accelerating new innovation in climate solutions.

Along with investments, Microsoft has been taking steps towards empowering others (Microsoft, 2021). One of their commitments is towards transparency and accountability. Microsoft recently launched a sustainability calculator which can help others determine their carbon footprint through their services for all three scopes. Microsoft suppliers are also required to report their greenhouse gas emissions and Microsoft has tried to increase transparency in regards to emissions generated by their products and services. Microsoft has also sought to be a vocal source for climate related public policy. For example, they sought to support more ambitious carbon reduction for a recent EU Climate Law.

Microsoft has made ambitious goals, but they have also shown significant progress in the past. They are amongst those doing what they can in the race for innovations to aid in the carbon emission problem. They have attempted to show others that it can be done and have encouraged them to try. With their carbon removal projects beginning to be implemented, and others being supported, it remains to be seen how the issue of carbon emissions will progress in the future. However, in order to bring about the necessary change, others must follow; "Microsoft alone cannot bring about this market change, and we are committed to forming alliances that can have catalytic impact" (Microsoft, 2021, page 30)

4.5 Amazon Findings

Amazon's keeps detailed records of their carbon emissions and publicly publishes this data. Amazon's total annual emissions are 51.15 MMT CO_2eq: of this 5.76 MMT CO_2eq being Scope 1 emissions (refrigerants from data processing and fossil fuels), 5.50 MMT CO_2eq are Scope 2 emissions (purchased electricity), and 39.91 MMT CO_2eq come from Scope 3 emissions (Apex Companies, 2020). Amazon distinguishes their Scope 3 emissions as "corporate purchases and Amazon-branded emissions," "capital goods", "lifecycle emissions from customer trips to Amazon's physical stores," and "other indirect emissions" (Apex Companies, 2020). A summary and the details of Amazon's carbon footprint for 2019 can be seen in Figure 9 and Table 2

respectively. The primary verticals of Amazon's carbon footprint are fossil fuels, cement, and packaging products.

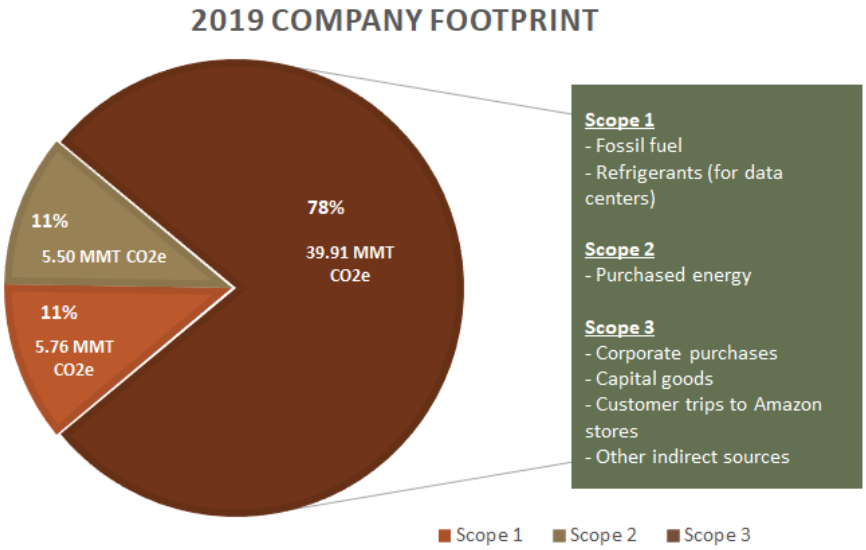

Figure 9: *Amazon Total 2019 Company Footprint (Data source: Apex Companies, 2020)*

Table 2: *Details of Amazon's Total 2019 Footprint (Amazon.com,* 2020-*a)*

Category of 2019 Emissions	MMT CO_2e
Emissions from Direct Operations (Scope 1)	**5.67**
Fossil Fuels	5.57
Refrigerants	0.19
Emissions from Purchased Electricity (Scope 2)	**5.50**
Emissions from Indirect Sources (Scope 3)	**39.91**
Corporate purchases and Amazon-branded product emissions (e.g., operating expenses, business travel, and Amazon-branded product manufacturing, use phase, and end-of-life)	15.41
Other indirect emissions (e.g., third-party transportation, packaging, upstream energy related)	12.44
Capital goods (e.g. building construction, servers and other hardware, equipment, vehicles)	8.01
Other indirect emissions (e.g., third-party transportation, packaging, upstream energy related)	4.05
Amazon's Total Footprint	**51.17**

The majority of Amazon's Scope 1 emissions come from fuel. The company's primary use of fuel is in delivery trucks and its airplane fleet that is used to deliver packages. Amazon owns 300,000 delivery trucks that are considered as a part of its Scope 1 emissions (Blanco, 2019). Similarly, Amazon owns 40 cargo planes, with plans to expand to 70 planes by 2023 (Davis, 2020).

Amazon also owes a large portion of its carbon footprint to its cement usage. The process of making cement releases carbon dioxide into the atmosphere. Amazon owns many large warehouses for delivering packages at seapores: Amazon owns 10 warehouses that each total 600,000 square feet (Davis, 2020). Amazon uses these large warehouses for delivering packages via major highways. Amazon owns 170 fulfillment centers with an average size of 773,000 square feet. Amazon uses "sortation" centers to sort packages by zip code: these 49 centers each account for 340,000 square feet. Amazon uses delivery stations to transport goods to their final destination, these are near major cities or airports: these 200 buildings are each approximately 129,000 square feet (Davis, 2020). These massive buildings account for a significant portion of Amazon's carbon footprint because of the cement, steel, and other building materials required to construct and maintain the facilities.

In 2019 Amazon joined The Climate Pledge, committing to reach net-zero across all of its business operations by 2040, 10 years before the goals presented in the Paris Agreement (Amazon.com, 2020-b). To accomplish this goal, they have committed to a combination of carbon reduction and offset techniques. Figure 10 below delineated their plans.

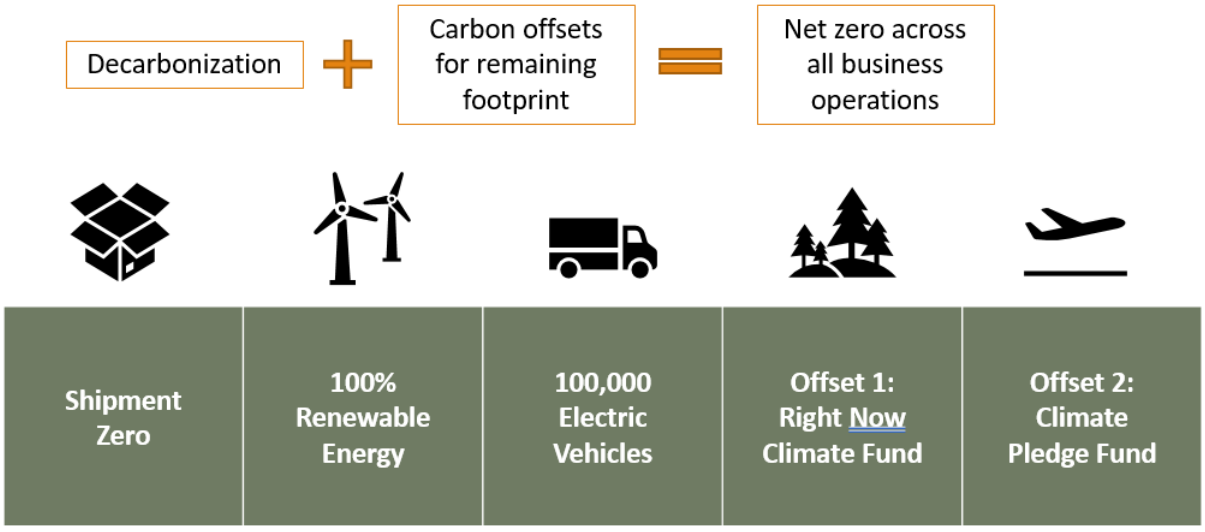

Figure 10: *Amazon's Actions Toward Net Zero Operation (Amazon.com,* 2020-*b)*

Amazon has pledged to implement a 100% renewable energy standard by 2050. So far, they are on track to achieve this goal based on their public documents and may even reach it as early as 2025. Amazon is using solar and wind power to meet this goal: investing in 206 projects globally

that result in 23 million MWh annually which cover 43% of the required electricity for Amazon's total operations (Amazon.com, 2020-c). If executed successfully this will shrink their company footprint by about 5.5 MMT CO_2eq, as this was their energy footprint in 2019.

Following Amazon's net-zero pledge, they have publicly announced their Shipment-Zero pledge. This pledge encompasses three major changes to Amazon's shipping process (Amazon.com, 2020-d). Amazon is looking to use 100% renewable energy in all of the warehouses that are used in the delivery process. To suppress the carbon footprint of its packaging, Amazon is seeking to use the original seller's packaging whenever possible and reach net carbon neutral packaging when this initial goal is not obtainable (Amazon.com,2020-d). Since 2015, Amazon has reduced the carbon footprint of its packaging by 33%: which accounts for more than 900,000 tons of material (Amazon.com, 2020-f).

Amazon is also looking to augment their fleet of delivery trucks with electric vehicles. Part of this goal involves the purchasing of 100,000 electric vehicles. This fleet of 100,000 vehicles would be more than three times their current fleet of 30,000. They are also trying to increase the efficiency of the non-electric existing vehicles by creating company-wide policies for optimizing tire pressure, delivery route, and mudflaps (Amazon.com, 2020-e). This part of Amazon's pledge is being implemented in partnership with Rivian.

Amazon has two offset pledges. The first is the Right Now Climate Fund which devotes 100 million USD to projects that improve land management, reforest, and conserve green spaces globally. As of 2021, Amazon has invested in two projects with part of this fund: reforestation in the Appalachians (10 million USD) and urban planning in Berlin, Germany (4.5 million USD). The first project, in the Appalachians, is predicted to capture 18 million metric tons of carbon dioxide from the atmosphere (Business Wire, 2020a). The company provides families who own forest land with tools and education on forest management practices to enhance the forest's natural ability. As of April 2020, Amazon has worked with families in Pennsylvania and Vermont but plans to expand to 4 million acres within and beyond the Appalachians (Business Wire, 2020a). The second initiative in the Right Now Climate Fund, provides The Nature Conservancy with funds for their Urban Greening project in Berlin, Germany. This project aims to make cities more resilient to climate change. The group works with city planners to increase urban biodiversity to encourage pollinators, reduce heat by planting trees and improving urban water areas, and reduce flood risk with tree planting, wetland conservation, and improving green spaces (Business Wire, 2020b). Amazon does not provide an quantified estimate of the carbon removal potential of this investment.

Amazon's second pledge is called the Climate Pledge Fund. This devotes 2 million USD toward companies that develop new and promising carbon removal or decarbonization technologies. As of 2020, Amazon has invested in the following companies: CarbonCure Technologies, Pachama, Redwood Materials, Rivian, and Turntide Technologies (Business Wire, 2020d). CarbonCure

Technologies has been described in Section 4.3. Pachama develops software to measure the carbon removal potential of forests and offers offsets for companies or individuals to purchase. Redwood Materials develops processes to recycle waste, primarily batteries. Rivian designs and manufactures electric vehicles and Turntide Technologies designs electric motors. Amazon does not provide a prediction of the potential carbon removal of this investment.

4.6 Amazon Analysis

This section discusses Amazon's two offset pledges, including the quality of the programs as successful carbon removal strategies. The section is concluded with an analysis of the steps they have taken to decarbonize their processes.

Amazon's First Pledge: The Right Now Fund

The Right Now Climate Fund is the closest Amazon has come to a legitimate offset program. Still this program has significant faults. Reforestation removes carbon dioxide from the atmosphere, and Amazon claims this will remove 18.5 millions metric tons by 2031. It is difficult to predict how much CO2 is removed by trees due to complexities in tree differences, age, and location. Despite this drawback, carbon is removed. Thus, this project can successfully claim additionality.

The leakage of reforesting in the Appalachians is in question. Reforestation is not a durable carbon removal program. Trees eventually die and release carbon dioxide back into the atmosphere. This can result in future leakage. Also, a significant portion of the forests in the Appalachians produces lumber. The lumber companies could move to another area and result in a negligible net change of carbon reduction. However, because Amazon works with family farmers, this leakage may be negligible because the forests may be selected due to lack of lumber production. Thus, this program has some leakage and durability failures.

The urban planning initiative in Germany has similar and additional drawbacks to the reforestation program. Trees and greenery eventually return carbon to the atmosphere as part of the global carbon cycle. This makes the durability low. Amazon is also funding the program to give advice to Berlin and surrounding cities rather than making active physical changes. Education is vital, but it cannot be considered a direct offset to produced emissions. Amazon also discusses climate benefits beyond carbon reduction, such as reducing flood risk and lowering the temperature of urban space (Business Wire, 2020b). This has limited effect on carbon dioxide in the atmosphere, further making it a poor offset program.

Amazon's Second Pledge: The Climate Pledge Fund

The Climate Pledge Fund at its very heart struggles to be a valid offset program. Few of the invested companies remove carbon dioxide from the atmosphere. Of the first five companies Amazon has invested in, CarbonCure is the most valid carbon removal technology: a cement that

uses carbon as a mineralization reagent. This company could partner with a direct air capture facility and thus make the overall process more feasible as an investment. The other four companies focus on decarbonizing technologies, recycling, or modeling the carbon removal of forests. These companies can be categorized as working to prevent emissions before they are created (or aid the reforestation process) rather than actively removing carbon. With this the pledge fails in its additionality.

The failure in additionality makes an analysis of the durability and leakage meaningless. Without carbon removed, there is no reason to determine if it will leak or remain in storage. The work of these invested companies is admirable and essential. Funding in such research and new products is vital to further the development of decarbonization or carbon removal technologies. However, these companies are not carbon removal programs. More so, funding given to these companies cannot be considered a valid offset program for emissions.

In summary, the intention behind Amazon's offset programs is valid. In their appropriate place, they serve an important role in reaching a future of less produced emissions and better managed or increased forest land. However, the carbon removed by neither the Right Now Climate Fund nor the Climate Pledge Fund can be accurately quantified. Amazon portrays the success of their net zero pledge as reliant on their offset program removing difficult-to-remove emissions. This must be the result of a large misunderstanding of offsets. This demonstrates the necessity of defining carbon removal terms well. The misunderstanding runs the risk of making Amazon look foolish or deceptive. The aim of this report is not to slander such a company but rather to suggest areas of improvement with the hope that a company like Amazon has the initiative and resources to respond with well-thought offset and decarbonization programs.

Amazon's Decarbonization Strategies

Despite their weak offset programs, Amazon has made admirable decarbonization efforts. Their efforts are summarized in the Figure 11 below.



	Shipment Zero	100% Renewable Energy	100,000 Electric Vehicles	Offset 1: Right Now Climate Fund	Offset 2: Climate Pledge Fund
Plan & Details	1. Clean energy centers 2. Carbon neutral packaging 3. Zero emission transportation	Using solar or wind power across all business operations.	Buying 100,000 from Rivian. Total trucking fleet is 30,000 trucks and 60 cargo planes.	100 million USD: Reforestation in Appalachians. Urban planning in Berlin, Germany. More projects to come.	2 million USD: Investment in visionary companies developing decarbonization technologies.
Progress & Evaluation	Complex –as of 2020, 33% reduced packaging. Delivery vehicles in progress.	Successful so far. 206 global projects: 23 MWh 42% renewable energy across business.	Significant move: 3 times more vehicles than current fleet. In progress.	Low risk but low additionality. Reasonable "offset program".	Important but no quantified removal. Not a valid "offset program".

Figure 11: *Analysis of Amazon's Actions Toward Net-zero Operations*

Amazon has targeted decarbonization in many different areas of their operations. This ought to be praised. Having a portfolio of approaches increased the stability of the system in the long term. If Amazon's offset programs removed more carbon dioxide from the atmosphere, their approach could be truly admirable and an excellent example to be emulated by other companies. Like Microsoft and Stripe, Amazon's response to the issue of emissions demonstrates the complexity of the issue. Carbon is embedded in energy production, equipment, building material, transportation, product usage, end-life. Despite this, small changes to items like packaging can make a significant impact. The ideal solution for many big companies appears to be first combining small changes across many areas, then switching to renewable energy for operations, and lastly investing in strong carbon removal technologies to offset emissions that are difficult to remove. The next section will similarly discuss the emission profile and reduction efforts taken by Unilever.

4.7 Unilever Findings

Unilever is a huge conglomerate of companies, which are broadly categorized into home care, personal care and foods and refreshment. They have made fairly lengthy and detailed pledges in all their divisions. Their overall goal across the entire company is to achieve net zero emissions from source to point of sale by 2039 (Unilever PLC, 2020). This implies that it is for Scopes 1 and 2 emissions.

Their home care is mostly laundry and cleaning products. The most substantial within home care was the removal of any fossil-fuel derived carbon from their formulas in favor of biodegradable ingredients by 2030. They note that ingredients are the greatest source of emissions from these

kinds of products. They state they will source the carbon needed for these products and their packaging from the "Carbon Rainbow" and phase out "black carbon," which is sourced from fossil fuels. The "Carbon Rainbow" includes carbon derived from plants, scrubbed from the atmosphere, from algae, and from recycled plastic. In addition to this Unilever has set aside a one billion dollar fund over the next decade towards their "Clean Future" program. It seeks to completely remove fossil fuels from all their products by 2030. This implies direct, Scope 1 emissions. The budgeted funds will go towards financing green biotech, CO_2 waste utilization, and low carbon chemistry to replace fossil-fuel derived chemicals. So far Sun brand dishwashing detergent now contains 70% 'naturally derived' ingredients replacing some fossil-fuel derived ones. The plan also involves establishing more circular economy principles into their packaging and ingredients. This includes using more recyclable ingredients in the packaging and establishing recycling programs in areas where their products are used (Unilever PLC, 2020).

Another pledge is to halve the net GHG footprint of their products by half for their entire life cycle. This implies Scopes 1, 2, and 3 emissions. This is calculated on a per consumer basis compared to 2010. Since then Unliver reports a 10% reduction across all products. This is further broken down into divisions relative to 2010. Foods and Refreshments has seen a 30% reduction, home care 37%, and beauty and personal care has seen a 10% increase. According to their analysis, this increase is mostly due to brand acquisitions that have GHG emissions that are higher relative to the average Unilever brand before. It is also noted that scaleup of renewables globally has been slower than Unilever anticipated. This means that the associated hot water use for example will have greater Scope 3 emissions for the personal care products.

Operations also has some specific pledges and strategies. Operations includes manufacturing, office buildings, R&D facilities, data centers, warehouses and distribution centers. The largest overarching plan they have put forth is for the entirety of their operations to be emissions free by 2030. This only includes Scopes 1 and 2. To do this they have the goal of meeting all their energy needs using renewables. By early 2020 all the grid electricity needs were met by renewables. This accounts for 51.9% of their energy needs, the rest coming from on site energy generation . Coal was also mostly phased out. Three factories globally still use coal on-site and 6 use coal indirectly since their grid electricity is partially sourced from coal. Some of the difficulties in cutting coal from these last companies are legislative. In the regions with the indirect coal usage some laws prevent them from switching to renewables (Unilever PLC, 2020).

In food and refreshment some of the greatest focus has been on increasing the efficiency of the refrigerants used. Specifically the shift was made to using freezers that use hydrocarbon refrigerants rather than traditional ones. Ben and Jerry's, which is owned by Unilever, supported a bill in the United States to allow use of these refrigerants. Hydrocarbon refrigerants are 28% more efficient than normal freezers (KaTom Restaurant Supply, 2020). Ben and Jerry's also produced some interesting statistics on the emissions from a single pint of ice cream, shown in Figure 12.

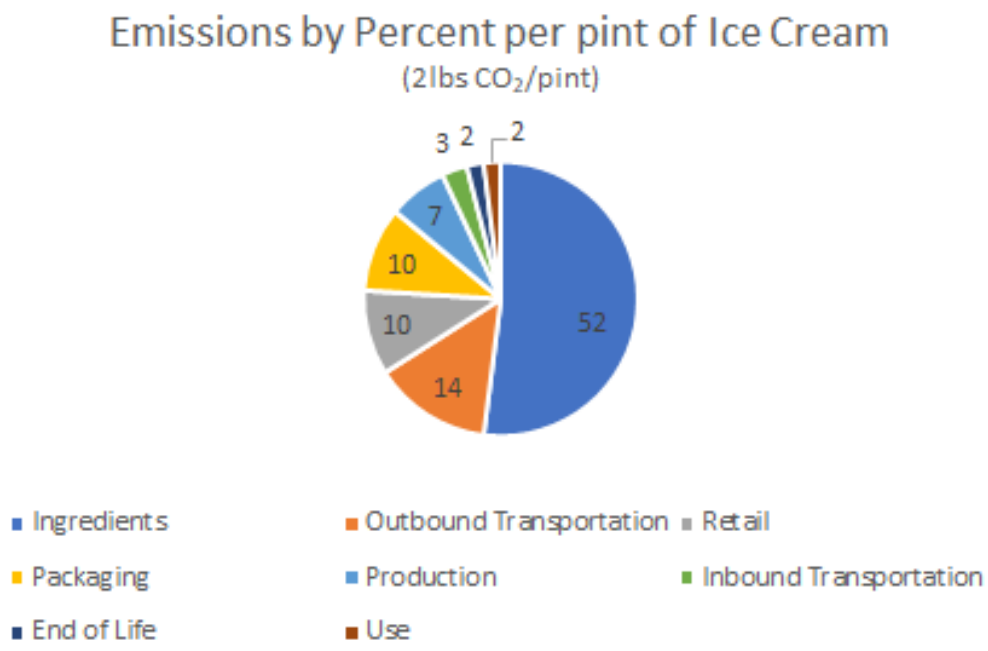

Figure 12: *The percentage of CO_2eq emissions produced over the entire lifecycle of a pint of Ben and Jerry's ice cream (Ben and Jerry's, 2015).*

41% of the entire emissions are all from dairy. As this is such a disproportionate chunk, Ben and Jerry's has been supporting a program which allows farmers to make bedding from cow's manure. This would divert 50% of the emissions that would come if the manure was just sent to landfill (Ben and Jerry's, 2015).

4.8 Unilever Analysis

Unilever has made many broad claims and pledges as well as implemented numerous footprint-reducing strategies. Broadly the plans seem to be effective thus far. Across all divisions except beauty and personal care they have seen sizable reductions in carbon footprint. These reductions are specifically for Scope 1 and 2 emissions, as they say they are only looking to reach net zero from source to point of sale by 2039. By Unilever's measure their emissions come mostly from Scope 3, and by a large majority. The breakdown is shown in Figure 13.

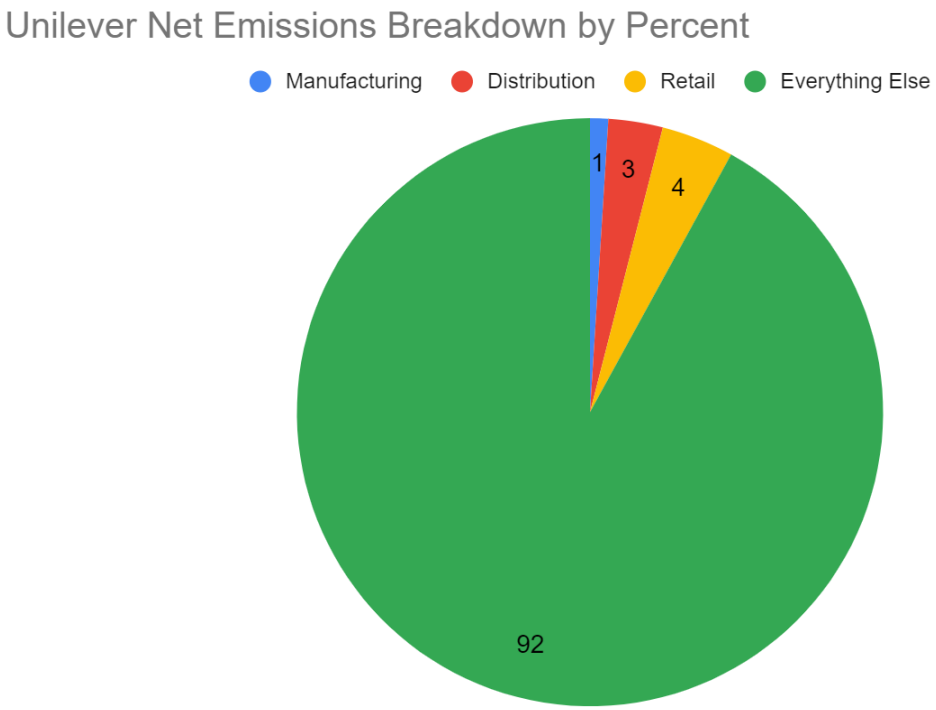

Figure 13: *Breakdown by percent for the total emissions created by Unilever. The "Everything Else" category includes all Scope 3 emissions as well as emissions created from sourcing ingredients (Unilever PLC, 2021).*

The emissions are dominated by everything excluding distribution, manufacturing and retail. This could all be considered Scope 3, depending on where the line is drawn of their supply chain ending. Since their focus is on minimizing Scope 1 and 2 emissions this is problematic. Unilever is a huge company though with a significant footprint, so minimizing even the small percentages of emissions is important. Cutting back Scope 3 emissions is naturally challenging. As it includes emissions associated with products end use it can be difficult to track all the associated emissions as they are out of Unilever's hands once sold. In many cases it may be up to the economy of the place of use to make the difference. For example, a shampoo product can never have zero scope three emissions if the process to heat the water creates emissions. Thus the scaleup of renewables is imperative to bring down these numbers. Unilever is investing in renewables, but it is important to prioritize where these are deployed (Unilever PLC, 2021). Replacing coal fired power plants will have better additionality than replacing a natural gas one. Clean electricity to power electric vehicles may have a better impact than using it for hot water. This kind of analysis is imperative for Unilever, as well as other companies and municipalities they operate in to consider.

Many of the actions and projects that Unilever are engaged in involve avoidance and mitigation rather than actual CDR. This shows in their home care division they were able to drastically reduce emissions by removing phosphates from their laundry products in their home care division. Emissions were considered across the entire lifecycle of the product, so it is an example of a

reduction that is considerate of additionality, as it will truly have an overall positive impact on the emissions as compared to doing nothing. It is important to note that they consider the impact of switching their composition to other 'green,' as advertised, ingredients. Obviously these other ingredients have some emissions associated with them, so some leakage in that sense, but have less emissions than the phosphates. They also are supporting and creating opportunities for their products to be part of a circular economy. This is particularly true of the packaging waste of many of their products. Recycling old plastics and sourcing material from renewable sources is superior for emissions than 'black,' fossil fuel derived carbon. On the whole, these projects that just avoid, or outright reduce emissions from their existing processes will be better from an additionality standpoint as compared to CDR. Leakage and permanence could also be better depending on what kinds of CDR they are compared to. It is shown that they understand this in Figure 14.

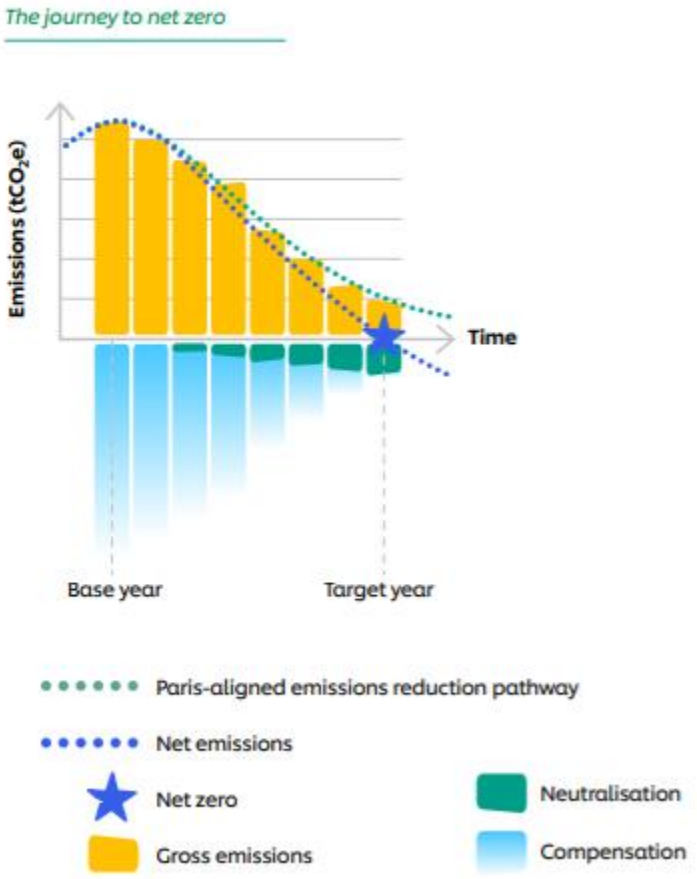

Figure 14: *Unilever's qualitative plan to achieve net zero across all their emissions using a mix of reduction and offsets.*

Some emissions may be unavoidable. This could include the methane from the cows that produce the dairy for their food products, or the emissions baked into the chemical processes to make their cleaning products. Thus some CDR will be essential for them to reach net zero. Unilever has committed to end any deforestation associated with the farming of crops for the production of palm

oil, paper and board, soy, cocoa, and tea by 2023. Afforestation's additionality and permanence are somewhat questionable, but preventing deforestation that was planned to occur technically represents a benefit. They also plan to perform some CCUS with CO_2 directly captured from industrial emissions. This is already performed for the soda ash from manufacture of their laundry detergents in India. While overall the CDR methods they employ are limited it seems Unilever is aware of some of the dangers. On carbon credits that can be purchased to offset "unavoidable" emissions, they note that this can simply serve to legitimize business-as-usual emissions growth. They note this can delay the necessary urgent actions that must be taken (Unilever PLC, 2021).

Unilever has a sensible and relatively comprehensive method of carbon accounting. They break down emissions for each part of their products from raw materials and packaging to transport and retail emissions. They also account for what Scope 3 emissions their products create which account for the vast majority of emissions. They consider the entire lifecycle emissions of their products as well, so in theory all long-term emissions are captured. This awareness extends to their actions as well. Scope 3 makes up the majority of emissions, but are challenging to abate. They take some actions, like providing support for legislation to allow for use of hydrocarbon refrigerants as well as implementing solutions to make recycling accessible and effective for their products.

5.0 Sector Analysis

Based on the selection criteria highlighted in our Methods section, our team chose to look at the retail, energy/oil & gas, hospitality, and agriculture sectors. The following sections summarize the pledges and strategies of four companies within each sector, and report on their emissions and any progress they've made. Following the findings is an analysis on trends found within the sector, and a look at what the companies did right or could improve on.

5.1 Retail Findings

The retail industry covers a broad range of products, from clothes to crafts and from furniture to tools. The four companies within the retail sector that we found to be exemplary were Nike, Patagonia, IKEA, and Walmart. They each did something impressive that warranted attention within their industry, and so became a figure for reducing their carbon emissions. Since we were limited to a small number of companies within an industry that has millions of contributors, these four companies are not a full analysis of the industry, but simply an example of what can be done.

Nike

Nike announced their Move to Zero pledge in September 2019 with 5 main initiatives:

1. Nike will power owned-and-operated facilities with 100 percent renewable energy by 2025.
2. Nike will reduce carbon emissions across its global supply chain by 30 percent by 2030, in line with the Paris Agreement of 2015.
3. Nike diverts 99 percent of all footwear manufacturing waste from landfills.
4. Additionally, Nike diverts more than 1 billion plastic bottles per year from landfills to create yarns for new jerseys and uppers for Flyknit shoes.
5. The Reuse-A-Shoe and Nike Grind programs convert waste into new products, playgrounds, running tracks and courts (Nike, 2019).

Nike is focused on reducing their emissions by increasing the amount of recycled material they use, minimizing their waste, and increasing the efficiency of transportation of goods. They are currently developing new recycled polyester and leather alternatives, including using old plastic from water bottles (Nike, 2020). Using recycled polyester has a 30% lower carbon footprint than virgin polyester, while recycled nylon reduces emission by up to 50% compared to virgin nylon (Nike, 2020; Nike, n.d.). Nike has innovated materials like Flyleather, which is an engineered leather material made with at least 50% recycled leather fiber, and Flyknit that creates 60% less scrap waste (Nike, 2020; Nike, 2021). Nike has many programs in place to minimize waste, including their Reuse-A-Shoe and Nike Grind programs. They are also a founding member of the Sustainable Air Freight Alliance, formed in 2019. It is a "buyer-supplied collaboration between shippers, freight forwarders, and air freight carriers to track and reduce carbon dioxide emissions from air freight and promote responsible transport," (Nike, 2020).

Their total emissions across all three scopes is 9.76 million tCO_2eq. Scope 1 accounts for 0.5% of their emissions, while Scope 2 accounts for 2.1% and Scope 3 accounts for 97.4%. As a company

who specializes in athletic footwear and clothing, the raw material phase of Nike's products accounts for 25% of their carbon footprint (Nike, 2020). This includes polyester, Ethylene-Vinyl Acetate (EVA) foam, rubber, leather, and cotton. The breakdown of emissions of the top 5 materials by volume for FY19 is in Figure 15.

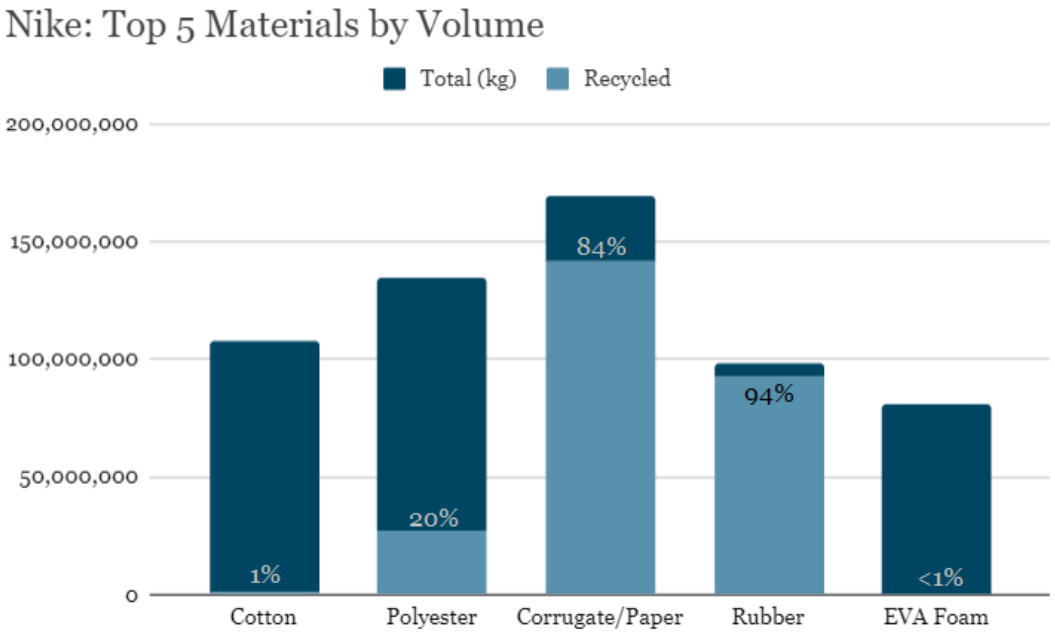

Figure 15: *Nike Total Weight of Materials Used in FY2019, Including Percentage of Recycled Material (Data source: Nike, 2020)*

Patagonia

Patagonia is smaller than the other companies represented in the retail sector, but they were chosen for their strong environmental ideals and progress towards creating products that produce less emissions. Their total emissions were only 228,440 metric tons of CO_2eq in 2019, with a plan to become carbon neutral by 2025 (Patagonia, 2019a). Patagonia is going to make that happen by having 100% renewable energy used for electricity at all globally owned and operated locations, reducing energy use throughout the supply chain, and using only renewable or recycled products by 2025 (Bustamante, 2019). With 86% of their emissions being due to the raw material phase, it just goes to show how much they've minimized their other emissions. Raw material emissions are generally a hard to reduce area, where emissions come from the extraction and processing to make it into a workable material. Patagonia's plan to further reduce these raw material emissions is to increase their use of recycled materials, develop low-emission dyeing techniques, and install energy efficient machinery (Bustamante, 2019; Patagonia, 2019b). Currently 78% of their products include recycled materials (Patagonia, n.d.). Patagonia says that their use of recycled materials in 2019 reduced their carbon footprint by 20,000 tons of CO_2eq (Bustamante, 2019). To offset their hard to reduce emissions, Patagonia is investing in regenerative organic agriculture, which is a form of carbon capture (Bustamante, 2019). They are also going to invest in other carbon capture

projects, like reforestation, with future plans to look into investing in carbon sequestration and deep-soil storage (Patagonia, 2019b; Bustamante, 2019).

Walmart

Walmart is the number one retailer in the world (National Retail Federation, 2021). Selling everything from groceries to wedding rings, they have both an extensive network of physical stores and a vast online marketplace, as seen in their ecosystem graphic in Image X. Their expansive network might make it hard to account for all their emissions, but they still have goals in place to reduce what they can.

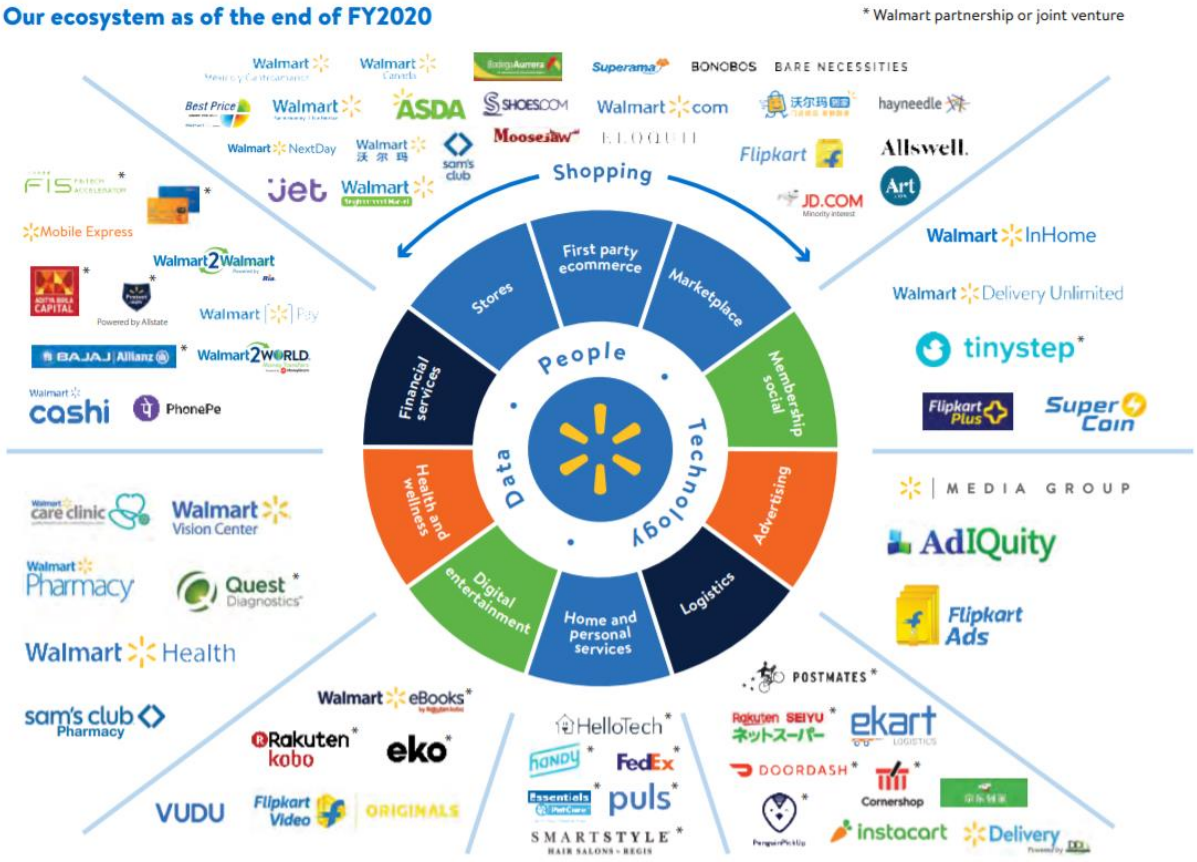

Figure 16: *Walmart Web of Subsidiaries and Affiliated Companies in 2020 (Walmart, 2020a)*

Walmart's main goal is to reduce all their emissions across Scope 1 and Scope 2 to zero by 2040. To achieve that, they want to power their facilities with 100% renewable energy, electrify and "zero-out emissions" of all their owned transportation vehicles, and switch to low-impact refrigerants and electrify their equipment (Walmart, 2020b). To address their Scope 3 emissions, Walmart created Project Gigaton which they co-signed with 2,300 of their suppliers to commit to reduce the emissions of the products they sell. They want to avoid a gigaton (one billion metric tons of CO_2e) of emissions by 2030 (Walmart, 2020b). This commitment covers six areas: energy

use, sustainable agriculture, waste, forests, packaging and product use (Walmart, 2020a). Walmart's final major commitment is to protect, manage, or restore at least 50 million acres of land and one million square miles of ocean by 2030 (Walmart, 2020b).

IKEA

As a homegoods store, IKEA's main verticals are wood (pulp & paper), plastic (polyester), steel and other metals, and cotton. As with other retail companies, IKEA has the majority of their emissions coming from the raw material phase, which accounted for 45% of their total emissions in FY20 (IKEA, 2021a). IKEA is very transparent and has publicly posted an entire breakdown of their company footprint (Figure 17).

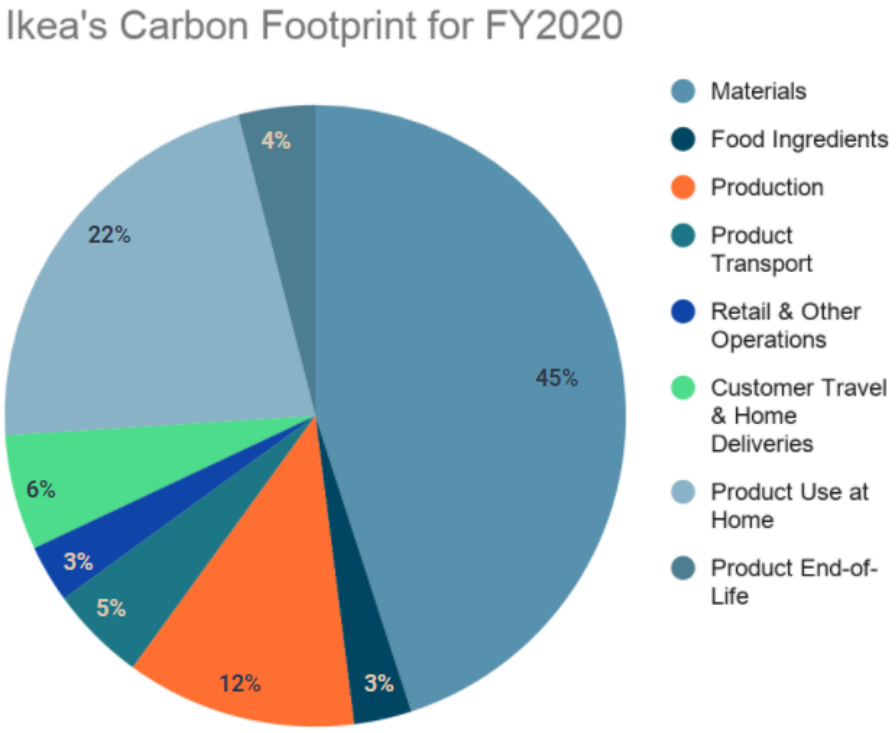

Figure 17: *Breakdown of IKEA's Carbon Footprint for FY2020 (IKEA, 2021a)*

IKEA is committed to becoming "climate positive" by 2030 (IKEA, 2021b). To do this they are going to switch to 100% renewable gas at all retail stores, only use renewable or recycled materials, and create circular products that have a longer lifespan with opportunities for recycling (IKEA, 2021b). To become a circular company, IKEA is focusing on using renewable and recycled materials to avoid raw materials, designing their products to be repurposed, reused, repaired and eventually recycled, as well as helping consumers find ways to extend the lives of their furniture (IKEA, 2020). Another aspect of their "climate positive" pledge is to invest 200 million euros into

making their supply chain run on renewable energy and into reforestation and restoration of degraded forests (IKEA, 2019).

5.2 Retail Analysis

Each company within the retail sector was chosen because they had promising pledges with obtainable goals and detailed plans. After doing a deep dive into Nike, Patagonia, Walmart, and IKEA, there were unique aspects of each company that stood out, as well as some room for improvement. Nike published a thorough sustainability report with details about their emissions, goals, progress, and areas for improvement. Their report was extremely thorough and considered aspects of their footprint that we initially hadn't considered. They also stood out because they spent time explaining why setbacks may have occurred and would touch briefly on their next steps to remedy them. Overall, Nike does a good job of both recognizing the need for change and showing the steps they are putting in to get there, along with highlighting that they need to stay on-trend and meet consumer expectations. Patagonia provides a good example of smaller retail companies. They're generally known as a more environmentally friendly company, so it's no surprise that they've reduced emissions not due to raw materials to 14% of their total emissions. Since they've done this already, they can now focus on reducing emissions due to raw materials. One place where we see room for improvement is in their offsets. Patagonia has committed to investing in regenerative organic agriculture and reforestation. While these areas are important, they are nature-based offsets and don't have high permanence or additionality. We think Patagonia could make their carbon reduction pledge stronger by investing in CCS.

Walmart is a good representation of large retail companies that own subsidiaries and span many types of products. First off, Walmart could improve by being more transparent about their carbon footprint. We found it really hard to break down their emissions, even trying to detect what percentage of their total emissions were due to Scope 3. It is understandably a hard thing to do with such a wide-reaching company, but it would make comparison to other companies an easier task. On the positive side, Walmart is showing a way to involve their suppliers in their emissions reduction, through Project Gigaton. They also had a lot of information in their annual sustainability report about the food they sell, specifically their produce and seafood. This wasn't discussed as much since the other retail companies we looked at don't sell the same products, but Walmart can be used as an example of a retail company that does have emissions due to food. Finally, IKEA's breakdown of their footprint was impressive and very informative. They included comparisons to their 2016 baseline, as well as explanations for their improvement or setbacks. IKEA also had good details about how they're creating circular products and generally becoming a circular company. The only improvement they could benefit from is having more details about how they're going to spend their 200 million euros, and more consideration for CCS.

Overall trends we found in the retail sector were that the easy to reduce emissions are in energy use, and the hard to reduce emissions are in the sourcing and production of raw materials. All four companies committed to sourcing 100% of their energy from renewables. They are approaching this by switching to renewable energy sources and investing in renewable energy projects when

they can't. For example, Nike signed a power purchase agreement with Iberdrola Renewables in Spain to produce renewable energy equivalent to 100% of their European electricity consumption (Nike, 2020). There was also a big emphasis to move to using recycled and renewable materials in the retail sector. This is especially important for materials like steel and concrete that have a large carbon footprint, and for the clothing industry which is a huge contributor to global emissions.

As seen in each companies' footprint, the most carbon-intensive step for the retail sector is the production of raw materials. From the four companies we looked at, the materials that produced the highest amount of emissions were polyester, cotton, nylon, wood, and steel. These are encompassed under the verticals: plastic, steel, pulp and paper, among others (cotton, produce, seafood, meat & dairy, wool, leather). Patagonia had the highest percentage of their overall carbon emissions due to raw materials and supply chain at 86%. This compared similarly to Walmart, who doesn't report their emissions but have an estimated 95% of their carbon emissions due to their supply chain (Stapczynski & Rathi, 2020). Nike and IKEA have a smaller percent of their emissions due to raw materials at 25% and 45% respectively. A graph comparing the total emissions of Nike, Patagonia, and IKEA with the percentage of emissions due to raw materials is shown in Figure 18.

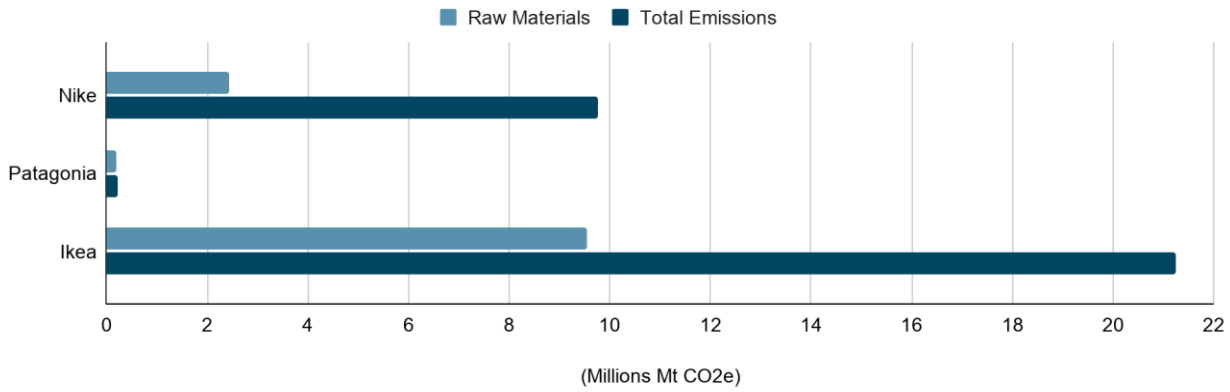

Figure 18: *Comparison of Total Emissions in the Retail Sector, Including Percentage of Raw Materials (Data source: Nike, 2020; Patagonia, 2019b; IKEA, 2021a)*

In terms of carbon offsets, the four companies we chose to represent the retail sector only mentioned nature-based offsets. While it is important to keep restoring and revitalizing the natural sides of our planet, it is actually not a great source of offsets. Nature-based offsets don't generally have long-term storage, and they are more likely to be disturbed by outside influences that re-release their stored carbon back into the atmosphere. Nature-based offsets also don't have additionality, which means that if someone purchased a plot of land to save the trees from being cut down, the logging company will still purchase land somewhere else and carbon will still be released into the atmosphere. Even though it is important for the retail sector to focus on reducing

their emissions first, they should consider CCS instead of nature-based offsets when it comes time for purchasing.

On the reporting side of things, the four companies we selected did a good job of considering all aspects of their footprint, not just the easy or hard to avoid emissions. We were surprised and impressed at all the small parts of the company that were considered for emissions reductions. This is an important consideration to make though, since that is how you achieve carbon neutrality. It shows that the companies understand the importance of reducing as much as they can before they turn to offsets to reach neutrality. Other companies that are looking to make progress in their own pledges should look to these four companies for an example of how to make many small goals as a good way to break down exactly where they want to reduce emissions.

5.3 Energy/Oil & Gas Findings

Four companies were examined within the sectors of energy and oil and gas. They were Total SE, which is a globally operating oil, gas, and energy company. Xcel energy was also examined. It is a United States based energy company. Repsol oil and gas was researched which operates globally. Lundin operates primarily in Norway, and is an oil company.

Total SE

Total SE has pledged to reach net zero specifically for all their operations by 2050. This includes Scopes 1 and 2. Within Europe, where they focus the majority of their operations they have pledged to reach net zero emissions across all scopes by 2050. So far across all operations they have achieved a 5% reduction as compared to 2015. Total invests in the global investment initiative Climate 100+. This initiative invests in implementing governance frameworks that will help fight against climate change. It also seeks to reduce GHGs across the entire lifecycle of the partnering companies. Enhancing corporate disclosure of their emissions and strategies is also a goal (Climate Action 100+, 2021). The majority of Total's strategies involve portfolio changes. Their progress is shown in Figure 19.

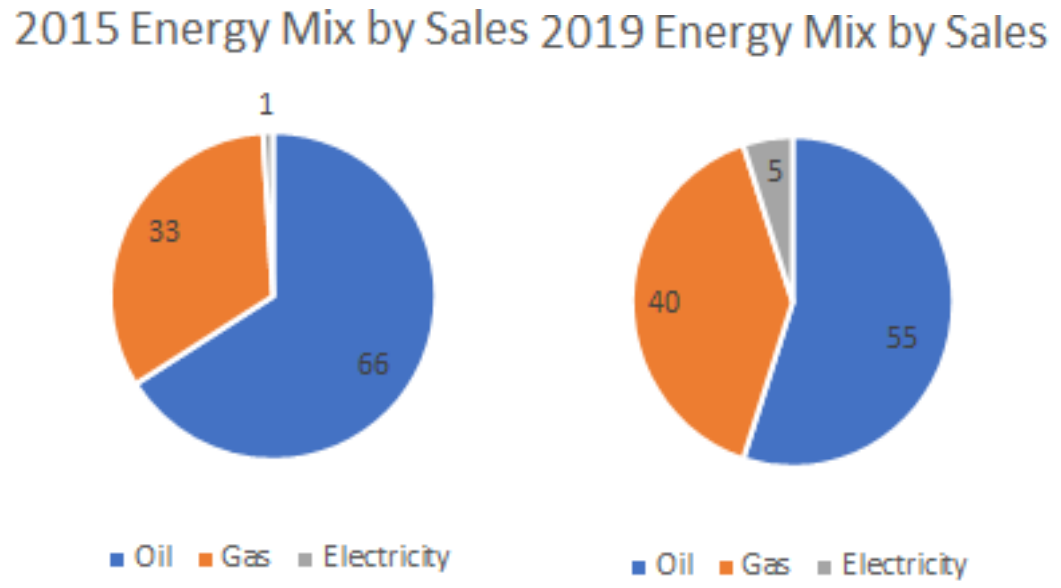

Figure 19: *Changes to Total SE's portfolio by percentage of sales. There are increases in both electricity and natural gas, while oil has decreased.*

This does not represent an enormous change, but increases in electricity and natural gas are beneficial since their emissions are less oil. Part of this comes from their scaleup towards low carbon electricity. They pledge to reach 25 GW capacity of renewables by 2025. As of 2019 they had just 3 GW capacity. In terms of their fossil fuel sales they intend to reduce their carbon intensity to 60% as compared to 2005. This only includes Scopes 1 and 2. As of 2019 they had achieved about 10% reduction (Total SE, 2020).

Xcel Energy

Xcel Energy has pledged to reduce their carbon emissions resultant of producing electricity by 80% of 2005 levels by 2030. After that their goal is 100% reduction by 2050. This implies that this is only Scopes 1 and 2 emissions. This does represent a majority of their emissions since the energy is created on-site through the burning of fossil fuels or renewables. In 2005 Xcel reported that their emissions were 44.7 million tons annually. A reduction of 80% would bring that down to 17 million tons. As of 2020, their emissions associated with electricity production are reported to be 38% of 2005 levels. This has been achieved through the phasing out of fossil fuels to create electricity. In place of where they were using fossil fuels they have switched over to renewables. They have implemented solar and wind as well vital battery storage that makes the renewables viable. Xcel has also focused on improving customer's energy efficiency, thereby stemming some demand and mitigating some emissions (Xcel Energy Inc, 2021).

Repsol

Repsol has pledged to achieve net zero emissions by 2050. They use a carbon intensity metric, they call a carbon intensity indicator (CII). It measures mass of CO_2eq emissions per energy

produced. This is calculated by including all scope emissions and subtracting any CDR or CCUS they have implemented. They have intermediary goals of reducing their CII by 10% by 2025, 20% by 2030, and 40% by 2040. They plan to achieve this through huge scaleup of low-carbon electricity. This includes massive investments into renewables increasing production of biofuels. Mostly this comes in the form of wind and solar energy. Repsol plans to make a large portfolio shift first away from oil and gas towards biofuels derived from vegetable oils. They plan to double their production with respect to 2020 to produce 600,000 tons of biofuel per annum in 2030. This will work to replace the need for traditional oil, and divert the oil from landfill where it might create more emissions without the benefit of its energy content. They also plan to increase the number of electric charging stations at their petrol stations which may serve to increase electric vehicle use (Repsol S.A., 2019).

Lundin

Lundin has targeted achieving net zero operational emissions by 2030. This only includes Scope 1. They use a measure of carbon intensity per barrel of oil equivalent (boe) produced. As of 2020 they have achieved an intensity of approximately 5 kg CO_2/boe. This is down from approximately 9 kg CO_2/boe in 2015. Their strategies involve large scale electrification. Since 2010 they have worked to electrify their oil rig facilities, so that they can ultimately run off entirely green electricity. This is accompanied with investing in renewable power generation. They have invested in approximately 600 GWh per annum. It is estimated that the projects will reach this capacity by 2023. Once this is achieved it will account for 95% of the energy used in the production of their oil. Alongside this they have invested in some carbon capture projects to reduce the final stretch of their emissions. They have opted for natural carbon sinks in the form of reforestation projects (Lundin Energy AB, 2021).

5.4 Energy/Oil & Gas Analysis

Only some of the investigated companies' pledges and strategies include all scopes. It is important to note the distinction between some of these companies and why the emissions scopes are vital to understanding whether these companies are making impactful pledges. For a company like Xcel, it's product is only the electricity it provides to customers, Scope 1 will be the greatest source of emissions. They produce the majority of this energy by burning fossil fuels, so this naturally is a dense source of emissions. For these kinds of companies to be focused on those emissions, Scope 1, this makes sense. Other companies that are selling the fuel should be focused on Scope 3. For example in Lundin's case, 97% out of all their associated emissions were Scope 3 (Lundin Energy AB, 2021). It is therefore problematic to see that a focus of their report was on reducing the operational emissions. Total SE seems to be somewhat aware of this based on their pledges, but specifically does not include net zero for worldwide emission across all scopes. Of the sources of emissions these are some of the most difficult for a company to get rid of. If the product they are shipping is just pure fossil fuel, the only options to mitigate that are offsets or changing the business model to be more focused on renewables. Offsets are expensive per ton of CO_2, and should really

be reserved for the kinds of emissions that are truly difficult to avoid. Therefore the focus should be on shifting portfolio and only using offsets to mitigate the final small emissions.

One interesting thing to consider is COVID's effect on some of these companies. Lack of demand for gas meant the prices tanked, so investments with a long ROI period like avoiding emissions might be dropped or receive less funding. This is short sighted, since, in part, COVID was made worse by the effect of climate change, and another pandemic is also more likely for the same reasons. If these companies had gotten their acts together soon and had less reliance on fossil fuels they might have taken a smaller hit. In the future it could be insightful to investigate its effects thoroughly after it has passed.

5.5 Hospitality Findings

One definition of the hospitality industry is "a broad category of fields within the service industry that includes lodging, food and drink service, event planning, theme parks, and transportation" (Wikipedia, 2021). For this project, four drastically different hospitality companies were studied including Hilton, Disney, the International Olympics Committee, and Starbucks. This section details their pledges, sources of emissions, and some of the steps they've taken towards achieving their goals.

Hilton

Hilton is a multinational company that manages hotels and resorts. They pledged to reduce their Scope 1 and 2 emissions by 61% and their Scope 3 emissions by 52% compared to a 2008 baseline by 2030 (Hilton, 2020). As of 2020, Hilton has stated that they are on track and their Scope 1 and 2 emissions are down by 32% across all hotels. Additionally, their energy usage, one of their major sources of carbon emissions, is down 24% across all hotels. From 2020, their scope emissions can be broken down as seen in Figure 20 (Hilton, 2021).

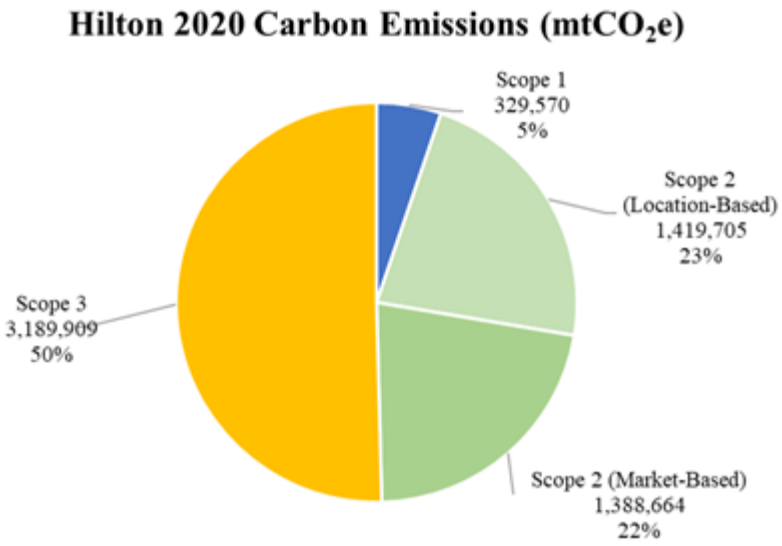

Figure 20: *Hilton's 2020 Emissions Breakdown*

From this, it can be seen that Hilton's emissions are primarily from Scopes 2 and 3. Some of the steps they have taken to achieve their goals are by installing LED bulbs, the use of renewable energy, and adding electric vehicle charging (Hilton, 2020; Hilton, 2019b). Some of their hotels have added solar panels and a 1.5 MW solar array was constructed in Maui. One thing that has to be considered with hotels is that the service they provide can encompass many aspects. In the case of a hotel, many hotels also provide food, thus creating a link with the agricultural industry. Hilton has committed to climate friendly food and sustainable sourcing for meat, poultry, produce, seafood and cotton (Hilton, 2019a). Towards this, they joined the Cool Food Pledge which aims to reduce emissions by promoting plant-based options (World Resources Institute, 2019). One effort is the release of their "Blended Burger" which substitutes in some mushrooms resulting in the generation of 29% less carbon emissions than a regular all-beef burger.

Starbucks

Starbucks is a coffeehouse with chains across the world. Their goal is to have a 50% reduction of carbon emissions across all scopes by 2030 (Starbucks, 2021). They have identified 5 main strategies to reach this goal: plant-based menu options, reusable packaging, agriculture and forestry projects, waste management, and innovation. In their 2018 environmental report, Starbucks released a complete breakdown of their emissions by percent, with their overall yearly emissions at 15.6 million metric tons (Figure 21).

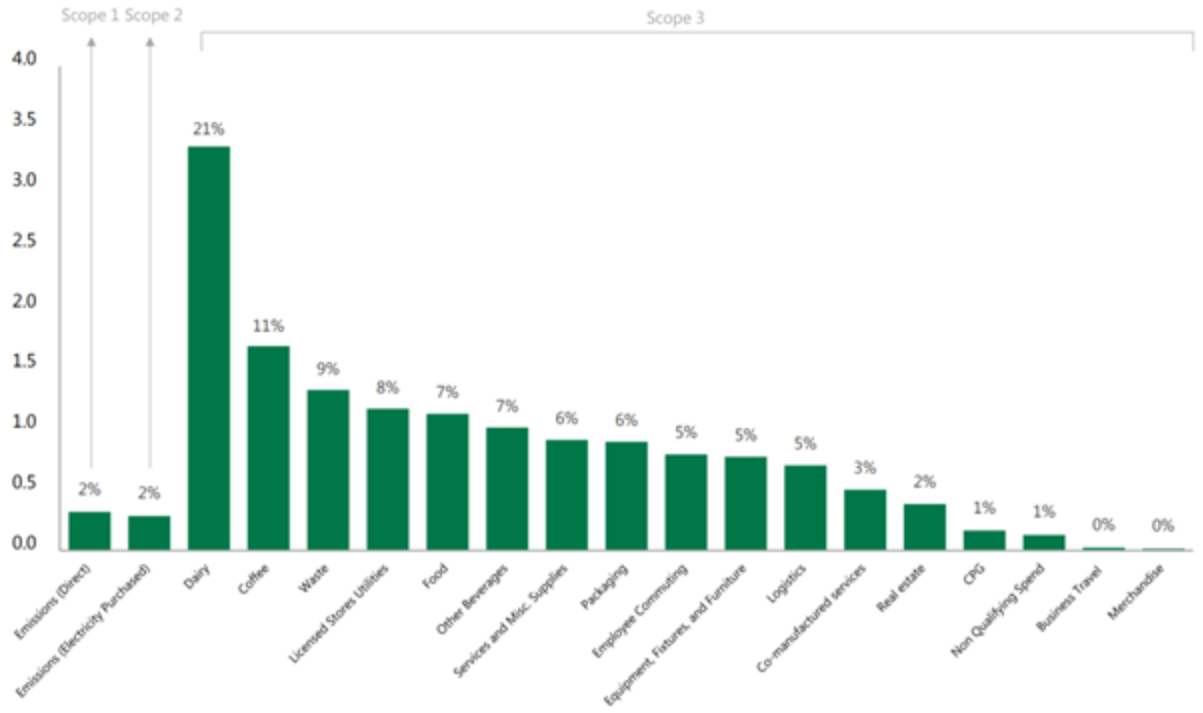

Figure 21: *Starbucks Supply Chain Emissions 2018 (Starbucks, 2020a)*

From this it can be seen that Starbuck's primary emissions come from their Scope 3, specifically dairy, coffee, and waste. Starbucks has been taking steps in order to reduce their energy by making their buildings up to LEED standards and by purchasing renewable energy (Starbucks, 2020b). Starbucks' goal is to purchase 100% renewable energy from RE100. As of 2020, Starbucks has reported the use of 72% renewable energy achieved through investments, offsets, and purchase agreements (Starbucks, 2021). Starbucks has invested in several solar projects in New York, Virginia, and California and a wind powered project is providing renewable energy in Washington (Starbucks, 2020d).

The International Olympic Committee

The International Olympic Committee (IOC) started adding climate agreements within the host contracts with a pledge to become carbon positive by 2030 (International Olympic Committee, 2020). For upcoming Olympic games, Beijing 2022 has committed to 100% renewable energy at venues, Paris 2024 is planning a 1.8M ton reduction compared to 2012 London Games (3.3M → 1.5M tons), and Milano Cortina 2026 and LA 2028 have committed to carbon neutral.

Already, the Rio 2016 games took steps to reduce and offset their emissions. With the Olympic Games, there are countless carbon sources to consider. In order to plan for the games, many venues, facilities, and athlete accommodations need to be prepared. Then the games themselves require planning for game operation, transportation, and spectators including their food and lodging. For

Rio, it was estimated that 43% of emissions would come from pre-planning and 57% from the actual games (Olympic World Library, 2014). New waste treatment and recycling centers were created and the city attempted to maximize the use of clean energy through Brazil's existing renewable energy grid, electric generators, and biodiesel. There was also a deliberate absence of parking in order to force the use of optimized public transportation. In an attempt to minimize construction, 19 of the 23 training facilities were already there and athlete accommodations were in an area already planned for housing construction. Additionally, Rio 2016 used offsets and reforestation for carbon removal. Forty-four hectares of new native vegetation were restored at the golf course, along with 7.3 hectares of natural vegetation in the Olympic Park (International Olympic Committee, 2017). The International Olympic Committee also created a partnership to work with Dow who has recommended carbon reduction methods for several Olympics and from whom the IOC has purchased carbon emission offsets (Dow, 2020). At Rio 2016, Dow provided 1.4 million tons of climate benefits for carbon emissions, and 5 million tons over the years.

The Walt Disney Company

The Walt Disney Company is an entertainment company involved in television, theme parks, merchandise, music, theatre, streaming services, hotels and cruises. Recently, Disney stated that their "ambitious" 2030 goal is to become net zero for their Scope 1 and 2 emissions (The Walt Disney Company, 2020a). Additionally, they plan to define a scientifically supported Scope 3 reduction plan by next year (2022). Disney had previously established the goal of reducing their emissions by 50% by 2020 compared to 2012, and recently reported success in accomplishing this goal (The Walt Disney Company, 2021).

One step in achieving their new goal is to have 100% zero carbon electricity for direct global operations by 2030 (The Walt Disney Company, 2020a). This is to be achieved by energy reduction, on site generation, partnerships with local utilities, power purchase agreements, and renewable energy credits. Their energy reduction plans started as early as 1996 where Disney Resorts partnered with the Energy Star Buildings program and implemented the EPA Green Lights program (Allen, 2007). These changes resulted in annual electrical savings of 46 million kWh by 1998. Another major accomplishment in energy was Disney's 270-acre solar farm constructed near Walt Disney World in 2019 (The Walt Disney Company, 2020b). It is capable of providing enough energy for two of their theme parks resulting in a decrease of emissions by more than 52,000 metric tons/yr. It is the second solar facility opened by Disney, the first being their Mickey Mouse shaped 22-acre facility opened in 2016. Disney has also sought to ensure any new construction uses minimal energy; their new space in New York was recently built to be LEED platinum, ensuring a sustainable design (The Walt Disney Company, 2020a). In addition to energy, Disney has also sought to use less fuel by replacing their bus fleet's diesel fuel 50% renewable. They are making biodiesel from their recycled cooking oil. They have also expressed a general interest in collaborating on low carbon fuel innovation. They have also sought waste reduction through reduction, recycling, reusing, and composting. Disney has also sought numerous nature and

forestry projects, with one result of these being carbon removal. Although one of the less comprehensive methods of removal, Disney has reported being responsible for the planting of over 9 million trees.

5.6 Hospitality Analysis

Companies within the hospitality industry have an interesting challenge ahead of them; many companies such as Disney and The International Olympic Committee have extraordinarily complex supply chains and distribution of operations. For example, just one of Disney's operations is their resort hotels, which means they have to account for emissions similar to Hilton's. Additionally, the IOC has to ensure there is lodging for athletes and spectators, so again, several hotel chains may account for just one emission source. Additionally, all four of these companies can be seen as needing to supply food, which results in another supply chain emission source, and another area for these companies to attempt their emission reduction. This also creates some overlap with the companies based in the agricultural industry. Due to all of the tasks that must be completed to run these companies, especially with constant work being performed for the IOC or expansion by Disney, all of the emission verticals mentioned in the background must be used. Given all of this complexity, it can be seen why Disney considers it a goal to establish a breakdown and reduction plan for their Scope 3 emissions.

The sources of emissions amongst these companies also vary. It is difficult to get a clear breakdown from Disney or the IOC, but Hilton and Starbucks have presented their scope emissions. For a company such as Starbucks, they have little Scope 1 and 2 emissions as they have little use for direct emissions and their energy demand is comparatively low. Hilton, meanwhile, needs constant energy to power their hotels. However, they have the same issue with high Scope 3 emissions. Another aspect to consider is that these are their recent breakdowns; both of these companies have been working towards carbon emission reduction for years which is easiest for Scopes 1 and 2. In comparison, there is a limit to Scope 3 reduction which is why offsets are used. All four of these companies have used some form of purchasing credits. This progress can be compared to Microsoft; they have worked towards their reduction and offset and will continue to make progress, but the next step to reaching net-zero would be carbon removal.

Of course, plans listed in the result section are just some of the companies' progress and their plans are constantly being updated. At the start of this project, Disney's primary goals related to 2020, but have since been completed and rewritten for 2030. Additionally, all of these companies are doing more than just emission reduction, as that is just one part of their true goal of environmental sustainability, although these concepts are often found to be linked. They have taken the first steps, but there is still a lot of work to be done.

5.7 Agriculture Findings

The food and agriculture industry are closely related and share many similar emission sources. This report combined the two for the sake of simplicity. The industry as a whole can be broken

down in two main ways: by supply chain location and by product category. An average food product will travel through three main hands: from the producer to a processing plant to a distributor (i.e. a grocery store or exporter). These three supply chain categories will have a distinct carbon footprint. For example, the main emission sources for a farm will be methane releases from animals, soil practices, and equipment fuel. For the processing facility, the main emission sources will be the energy used in the process. For the distributor, the main emission source is in the transportation of the product and the energy used in the store location. Defining a footprint of an agriculture and food company is difficult because of these three main supply chain steps.

Another way to categorize agriculture and food companies is by their main product. The categories can be split by dairy, meat, eggs, grain, produce, seeds, farming equipment, and farming materials (i.e. fertilizer). Each of these will have a unique footprint and there will be trends within each grouping. Thus, when analyzing the footprint of any agriculture and food company one must consider where the company is along the supply chain and what their main product is.

This report analyzed four specific food companies due to the availability of information: Annie's, Organic Valley, Campbell Soup Company, and Danone. The next section compares their pledges and major emissions sources.

Annie's

The first food and agriculture company analyzed for its carbon footprint was Annie's. Their pledge includes measuring its environmental impact, using and teaching soil practices that enhance carbon absorption, and transition to 100% recyclable packaging (Annie's, 2012). Annie's total company footprint in 2015 was 12,858 tCO_2eq (Annie's, 2015). The scope of this footprint was found by compiling data from 2012 and 2015: the company's energy usage in 2012 and their 2012 percentages of carbon intensity for activities such as material production and packaging. Figure 22 below shows this breakdown.

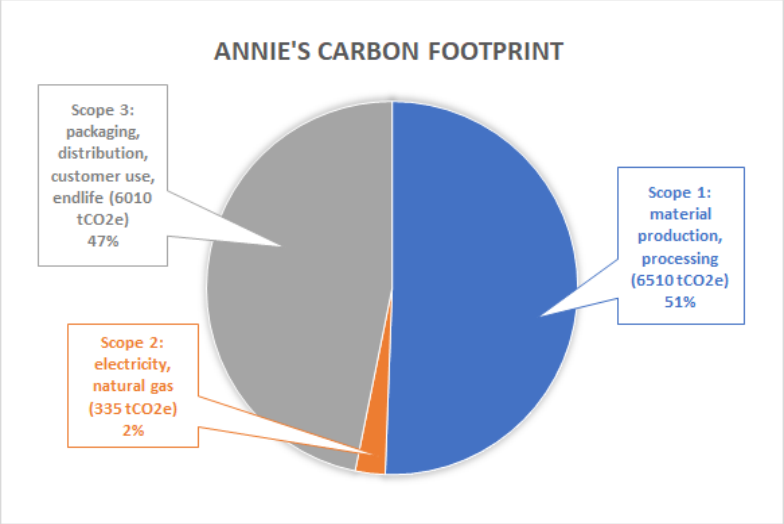

Figure 22: *Annie's Carbon Footprint Data*

Organic Valley

Organic Valley, the second company included in this portion of the analysis, pledged to aim for carbon neutrality (Organic Valley, 2018). Their carbon reductions include making energy efficiency improvements in their office spaces, operating facilities with 100% renewable energy, and using biofuel and updated route logistics to reduce their carbon footprint from transportation (Organic Valley, 2021). Organic Valley's offsets investments are in reforestation efforts: investing in projects in the Amazon Rainforest and California, with the latter purchase looking to offset 1,000 tonnes of CO2 per year (Organic Valley, 2021). Organic Valley is also implementing extensive changes to their farming processes, enforcing that their partnered farmers use climate smart farming to reach carbon neutrality across all of its farms (Organic Valley, 2021). Organic Valley speaks highly of transparency but does not provide detailed footprint data (Organic Valley, 2021). They do not seem to track it themselves. A partial footprint is shown in Figure 23 below.

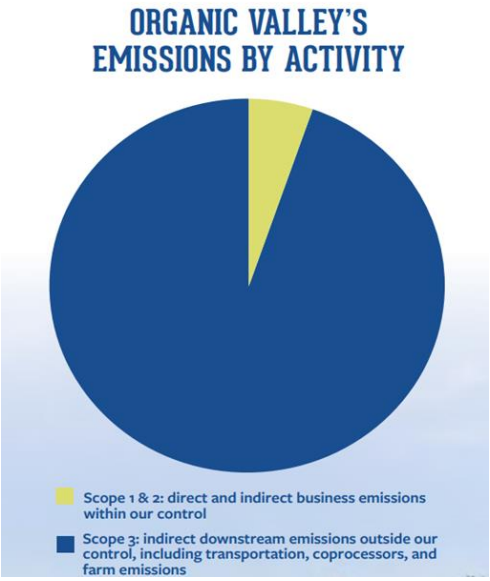

Figure 23: *Organic Valley Carbon Footprint (Organic Valley, 2021)*

Campbell's Soup Company

Campbell's Soup Company is famous for its soups but also owns subsidiaries such as Pepperidge Farm, V8, and Snyder's of Hanover (Campbell's Kitchen, 2016). The company pledges to reduce its Scope 1 and 2 greenhouse gas emissions by 25% on an absolute basis by 2025, using its 2017 emissions as a baseline. Campbell's aimed to source 40% of their electricity from renewable sources by the end of 2020: it is unclear if they met this goal in the midst of a global pandemic. Campbell's also sought to reduce greenhouse gas emissions per short ton of tomatoes by 20% by the end of 2020, using 2012 as a baseline year. Similar to Annie's and Organic Valley, Campbell's is looking to transition to 100% recyclable packaging by 2030 (Campbell's, 2020). Figure 24 below shows Campbell's 2019 carbon footprint.

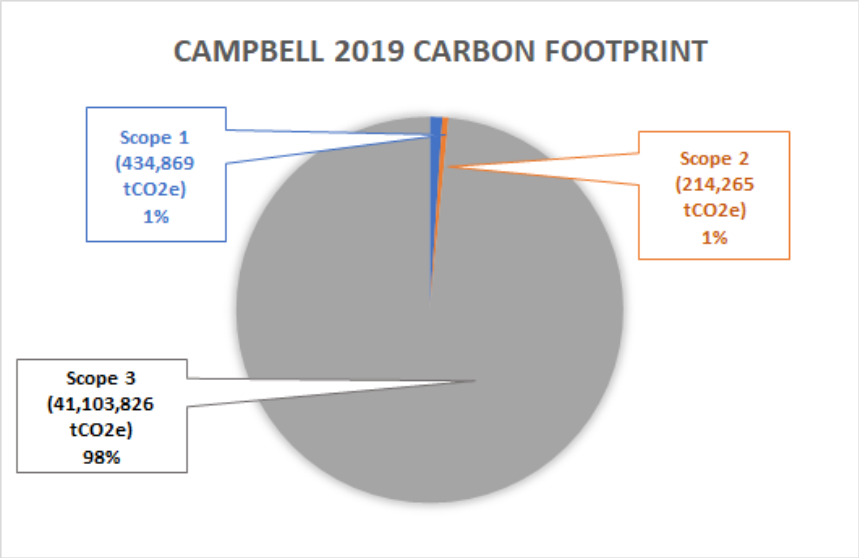

Figure 24: *Campbell Soup Company 2019 Carbon Footprint*

Danone

The last company analyzed from the food and agriculture sector is Danone: with a goal to be carbon neutral by 2050. Danone is primarily a processing and distributing company. Danone is looking to implement carbon reductions to diminish their Scope 1 and 2 emissions and use offsets to counter their Scope 3 emissions. Danone's major source of carbon reductions come from its pledge to use 100% renewable energy. Most of Danone's offsets are investments in reforestation projects (Danone, 2019). Their footprint is shown in Figure 25 below. Figure 26 also shows their footprint in more detail, particularly showing the high emissions from dairy operations.

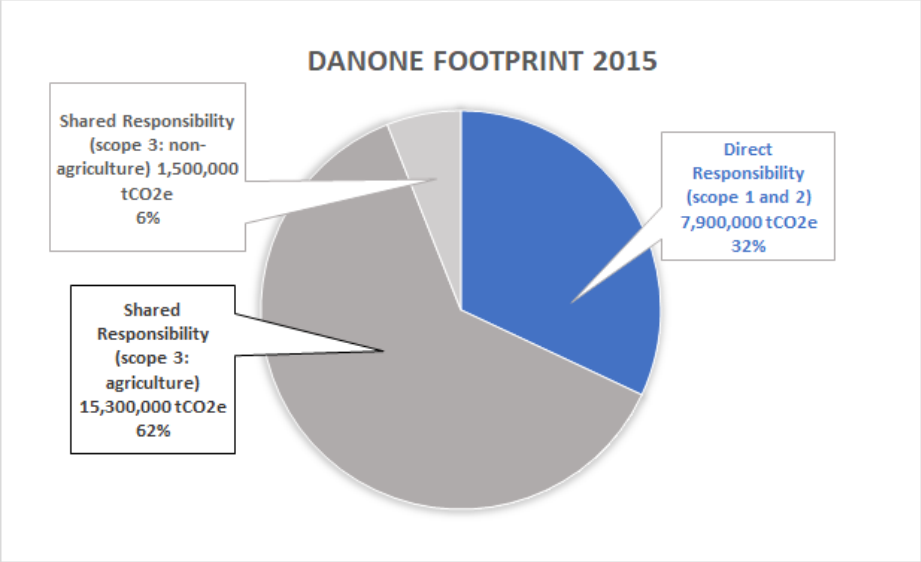

Figure 25: *Danone Carbon Footprint (Danone, 2016)*

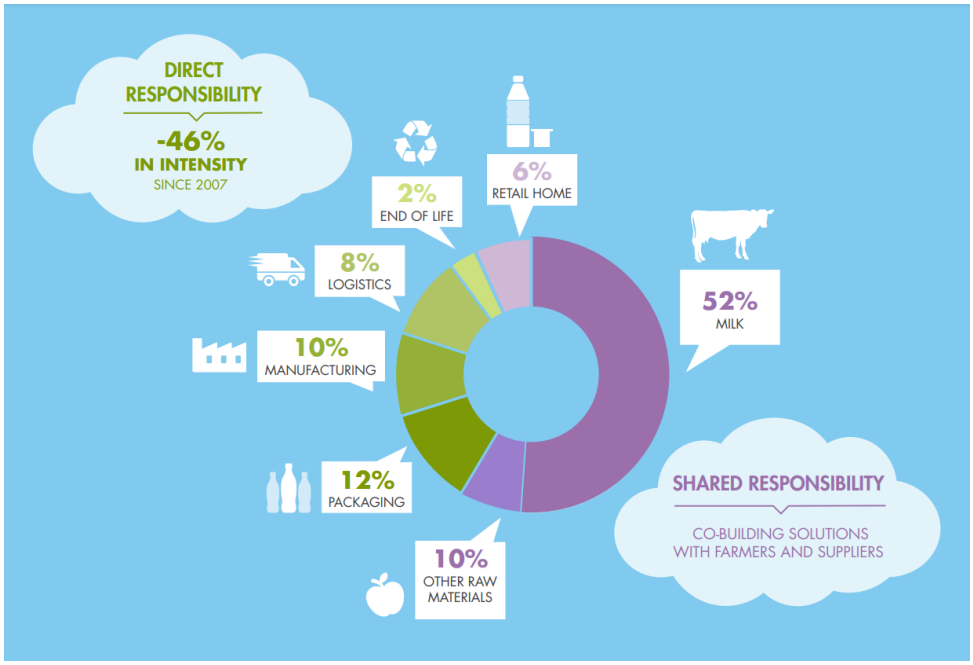

Figure 26: *Dannone's Footprint Demonstrating the High Impact of Dairy Operations (Danone, 2016)*

Comparing the four food and agriculture companies analyzed in this project, it can be seen that the main emission sources for all four cases primarily comes from the material production, especially in dairy related operations. If the company produces their own material, such as Annie's, Scope 1 contains their major emissions. If the company is a processing or distributing company, such as Campbell Soup Company or Danone, Scope 3 contains their major emissions.

5.8 Agriculture Analysis

Agriculture as an industry has a huge footprint: 10% of total US greenhouse emissions (Environmental Protection Agency (EPA), 2019). For comparison, all residential and commercial energy is 13% of total US greenhouse emissions (EPA, 2019). The Institute for Agriculture and Trade Policy found that the annual emissions produced by "the world's top five meat and dairy corporations—JBS, Tyson Foods, Cargill, Dairy Farmers of America, and Fonterra" exceed that of ExxonMobil, Shell, or BP (Institute for Agriculture & Trade Policy, 2018). Figure 27 below demonstrates that the majority of these emissions come from agriculture production: the disruption of healthy soil, soil management practices and the application of fertilizer (Farm Bureau, 2021). Other practices that contribute are manure management practices, rice cultivation, biomass residuals, field burning, and fuel use on farms (Farm Bureau, 2021).

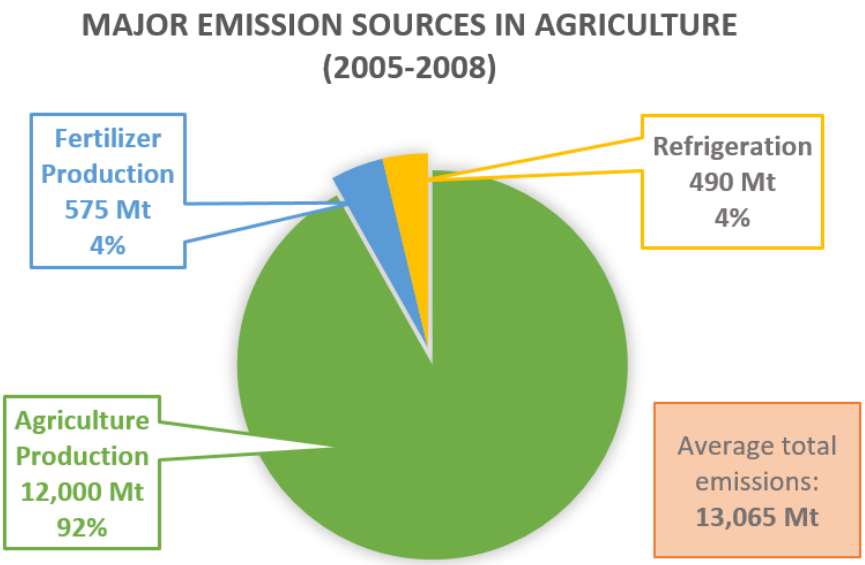

Figure 27: *Major Emission Sources from the Agriculture Industry from 2005-2008 (*Vermeulen, 2012*)*

Food and agriculture companies are thus in a distinctly interesting position when making plans to curb their carbon emissions because of this naturally complex relationship with the carbon cycle. Food and agriculture companies exploit soils and natural resources to raise the crops that will eventually become their final products, there is a natural carbon cycle embedded in their business structures. Similarly, food and agriculture companies do not publish their methane emissions with the same granularity as their carbon footprint when the cows that produce dairy resources release mass amounts of methane into the atmosphere. The companies that do address their methane emissions from the dairy industry are purchasing offsets instead of investing in ways to limit the methane emissions in cows, likely a difficult task.

Comparing the four companies in this study can provide insights into the carbon reductions and offsets efforts by the food and agriculture sector, although not necessarily a representative sample of all food and agriculture companies. Overall, smaller companies tend to have climate goals more frequently than larger companies. If a larger company does have a goal, like Tyson, they tend to not be ambitious: Tyson aims to reduce 30% of its carbon footprint by 2030 (Tyson, 2019). A potentially influential factor in the ambition of a company's pledge is the income level and interest of the company's target audience: where the pledge acts as a sort of marketing technique to customers. As an industry, food and agriculture companies appear to have a low interest in implementing sustainable practices that would reduce carbon emissions. Unlike mega-corporations, like Amazon, there tends to be a lack of media coverage on the carbon emissions of food and agriculture companies.

There are a number of viable techniques to reduce and offset the carbon footprint of companies across the food and agriculture industry. The first is improving soil management practices.

Quantifying the impact of these changes is incredibly difficult, but could still have a large impact. Companies can also implement renewable energy standards for their corporate offices and convert to more energy efficient practices in office spaces. Similarly, companies can purchase electric farming equipment to lower the emissions resulting from combusting fuel. They can also reduce the amount of packaging used per each unit of product and use recyclable materials to have a circular packaging process. The food and agriculture sector should practice investing in quality offsets because of the many difficult-to-avoid emissions embedded in their process. Namely, the food and agriculture sector is limited by the greenhouse gas production of cows in dairy processes and in the transportation of their products from farm to table.

6.0 Conclusions

6.1 Corporate Recommendations

Based on our findings and analysis, we are going to make a few recommendations for companies looking to make a carbon reduction pledge. This study found that most companies tend to replace their energy needs with renewable energy somewhat quickly and seamlessly. Thus we first recommend that companies switch to using wind or solar energy. Doing so can reduce a large portion of a company's emissions. If the company cannot afford to create their own renewable energy farms, we suggest that they look into leasing energy from a nearby energy farm.

Second, we recommend that companies model their carbon footprint. This can have a threefold benefit: identifying company activities that can be decarbonized, proper reliance on offsets, and increased accountability with pledges. Quantifying a corporate carbon footprint is a daunting task for most companies, especially for Scope 3 emissions. However, the benefits are great and can give a company a great advantage in successfully accomplishing their sustainability goals. If a company doesn't know their emissions, their plans to reduce them are uninformed: you can't improve a problem that's not well defined. In modeling a company footprint, unexpected emission sources can also be identified. We found that the companies that modeled their footprint pursued more creative and varied decarbonization methods which resulted in a greater total emission reduction. Modelling a carbon footprint also shows what emissions are easier and more difficult to remove. By seeing the scale of each, a company can develop a strategy to first decarbonize the easier to remove emissions, increase the efficiency in the processes with difficult to remove emissions, then lastly turn to offsets to remove the residual emissions. In contrast, by starting a sustainability plan with offsets, a company may ignore processes that should be decarbonized and thus perpetuate the problem of emissions. The third benefit of modeling a corporate carbon footprint is the accountability given to the public or to the company internally to track the success or failures of sustainability actions. This can be used to reassess plans for optimal emission reductions.

Lastly, we recommend that researchers who want to support the cause of reducing corporate emissions should aim to make developments in the fields of shared emission sources, such as transportation, automobile fuel, packing, and building materials. By developing a solution for a shared emission source, the emissions of many companies can be reduced.

6.2 Recommendations for Future Research

We have two suggestions for future research in this area. The first is to study and compare more industry sectors. Example sectors to look into include aviation, software, construction, financial, health and wellness, and manufacturing. One suggestion is to create a more detailed and quantitative table of verticals. This could better identify the verticals that need decarbonization and the potential quantitative impact of such improvements. Our second recommendation is to look at companies who have failed or struggled in their sustainability pledges. What leads these

companies to struggle? What could be improved to help their attempts? How can a consumer, other companies, or researchers support companies to make strong goals and follow through.

6.3 Closing Remarks

The realm of corporate sustainability is relatively young. This means pledges and actions taken by companies can be updated every few months or years. Some make ambitious plans and follow through while others change their goals to be less ambitious after realizing the difficulty. Some companies claim to highly value transparency and sustainability while not providing clear answers of what their company is doing or following through on their pledges. Some companies are making high goals, following through, and carefully reporting their learning. This realm could be approached with a pessimistic or optimistic view. The takeaway from our findings could be that companies could make stronger pledges, take more action, and be more honest about their sustainability failures when they occur. Alternatively, the takeaway could be the difficulty of decarbonization and yet the number of companies that are identifying sustainability as a need. The conversation about sustainability has increased greatly over the last 30 years, and companies are listening. We hope that this report can encourage the companies that are trying to make a difference while encouraging others to take a step toward decarbonization. We hope to forward the conversation around corporate emissions and corporate power to make significant changes to better the planet.

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Appendix

Interview with Ryan Orbuch

Conducted on March 12, 2021 by Marissa Breeden, Alexander Jensen-Fellows, and Madison Perry

How did Stripe come to start measuring and planning to mitigate its environmental impact? (Madison)

- Stripe did not have a specific date,
    - "We see our emissions reductions and carbon removals as pretty separate, and that is a useful way to look at it"
- "At a high level, this is a few years before I joined the company, our leadership had been interested in climate for a while. In 2017- we did our scope analysis. At that point our emissions up to scope three were pretty small, 20-30,000 tons."
    - "Primarily data center driven, energy use, food, facilities"
    - "We're in a much easier position than some companies in our day to day operations."
- "Bigger companies are totally different things. We have a way to go in terms of reductions that are in progress but our company is fairly straightforward."

What are some widespread challenges to decarbonizing the private sector? (Alec)

- "We're working on power purchasing and facilities reductions, which are on hold now because of covid right now, the office emissions are very low right now."
- "Most of our work is investing in carbon removal systems: recognizing emissions and removing what we are emitting"
- "We haven't fully completed a power purchase yet, cant speak to that in more detail"
    - Major criticism of these systems are additionality concerns, the power will sell to the grid anyway so you buying is kind of arbitrary.
        - Ryan offered to send resources on this point.

How did you get started working with Stripe's climate team? What are your roles and responsibilities? (Marissa)

- "Stripe made the original carbon removal commitment when I was working on a different team. The guy who started our commitment is now at a company called WaterShed"
    - "We use them (WaterShed) for our own footprinting and power purchasing"
- "I had long been interested in climate, started working on it on the side. I read a bunch of content and became interested in CCS, convinced leadership to turn it into a full team of 6 people."

- "Originally, I worked in project management but now I work on our purchases. I run with scientists on revising projects, development of project applications, and deploying funds in a way that is most effective"

How does Stripe choose carbon reduction and offset projects to invest in? (Madison)

- "We don't have traditional projects, we have an in-house validation process. We make a public call for proposals based on a set of criteria"
- Accelerating ideas and scaling down cost curve
- "We run an internal peer review on applications. We ask experts to run the applications, and give feedback. My team ends up making a purchase decision off of that."
- "This is ridiculous to expect companies to do this. Experts don't have infinite time. This doesn't make sense. We want users to benefit from our diligence and portfolio development. There are credit markets that should do this, but they don't work."
    - "Doesn't make sense for each individual company to do this themselves, hopefully we can help do it on behalf of many"
- "We loop people in based on how interested they are and how much time they have. Some people we talk to all the time, others we loop in as we dived into individual applications"
    - Worked with Roger Aines at Lawrence Livermore National Laboratory, "they helped us learn what questions to ask"
    - Carbon Plan
- "After we receive the application and review sheets are filled in, we ask them (experts) early so they can usefully review the project. These (application) questions will help experts make credible determinations about validity."
- Can you talk more about why Stripe doesn't invest in nature based solutions?
    - "There is good research from Barbara Hyatt and others that forest credits, conservatively, 80% dont have additionality "
    - "Our criteria is about minimal arable land use and permanence so forest and soil are out"
    - "We evaluated them in partnership with soil and forest experts, we could not get comfortable with the permanence and additionality- there is plenty of money going into forests- we don't think we could make that much of a difference"
    - "There are issues in the accounting that seems serious- leakage issues are shitshows"
        - "History of investing in forests without these issues being properly addressed or accounted for"
    - "To say nothing of the arable land issues are, we found a way to characterize the solutions with arable land use that scales well with land use because land is scarce"

    - "A permanency plan with land use means we don't want to be in the business of underwriting land owners and seeing how cheap they are"
    - "We couldn't figure out how to do it that made sense and other areas needed investment more"

In your own words, how does Stripe Climate make carbon neutrality accessible to businesses? (Alec)

- "We are currently in the process of expanding the portfolio"
    - "They can contribute and we can expand the portfolio in the background,
- "We want long-term commitments, don't have enough money for everyone yet"
- "We don't do carbon neutrality, we don't promise that. The premise is not to footprint themselves and then make it equal."
- "Problem with neutrality is that you have a target number of tons, hard to justify high cost for that target"
- "We take a small percent from our clients. We consider it like a tax, we then deploy the money usefully"
- "If you're trying to get to neutral, you're not going to do that [with Stripe Climate]"
    - "We are providing an alternative to neutrality, something that is more likely to solve the problem"
    - "The idea of neutrality is kind of arbitrary"
- "Independently, they can start trying to change business practices to reduce emissions"
    - "We are not trying to fulfill all of their sustainability goals, we are hopefully making carbon offsets accessible to them so they can focus on carbon reductions"
- "We hope companies become more comfortable investing in this way instead of making arbitrary claims about emissions"

Are there any specific companies or organizations that you look at as role models in this field?

- We were trying to do something different than what other companies before us had tried to do
- A lot of companies worked well in analogous areas that we took inspiration from
- Google early clean power purchasing in the early to mid 2000s was super impressive, accelerating renewables in the US meaningfully
    - Novel power purchasing markets, real financial risk- being genuinely additional in renewable projects
    - We want to be a demand signal, that's how we can be most useful to the field- that's what google understood
- Government procurement
    - NASA program COTS (commercial orbital transportation services) is what eventually commercialized SpaceX
    - "We talked a lot to the people at NASA about this"

- They wanted to help create the commercial space industry, at a time when there were a couple of commercial entities. They wanted to incubate a commercial space industry. They (NASA) wanted to eventually serve as the customer, but to get there they had to support the entities in a specific way."
- How can you ladder governments to get to procurement? Setting milestones for a decade helps make technology cheaper!
    - Technology Learning Curves
        - Book: Greg Nemmit, "How Solar Got Cheap"
            - Deep dive on policy and market mechanisms across a range of solar development
            - International tracking of manufacturing and IP Pipeline
        - Ryan thinks about how these principles might apply to DAC
        - Writes law of manufacturing (airplane manufacturer)
            - Links and information available on Ryan's website
            - Cost per unit will scale with volume of production
        - Solar took 70 years with an 18% learning rate
            - Alternative structures can speed this process up
            - Climeworks vs Carbon Engineering
                - One is super CAPEX heavy
                - One is super OPEX heavy
                - Different cost reduction potentials
            - "In CDR, each technology is different which makes it hard to bench mark."
                - "This is why we prioritize transparency: learning rates."
                - "Learning curves are understudied in economics."
                - "Things won't get cheap unless they scale. Debates about expensive costing are meaningless"
                - "Nuclear is weird about regulatory stuff"
                - "We should give tech a chance to get cheap"
    - Sabine Fuss is doing cool work, paper with Greg about modeling bottle necks and cost projections
    - Central repository of TEA to compare technologies, better way to figure out how fast a project is learning

With DAC being new, we have to extrapolate its future costs. How do you justify the optics early on?

- There aren't that many DAC companies, mainly 2-3 options
- We have been trying to find an analogy for modeling reserves in a portfolio
- Start up Venture Capital:

    - Seed funding rounds and later rounds, each round the company needs to prove itself on a series of criteria.
    - If I am a venture fund, I want enough money to double down on them in the next round balanced with seed checks for other projects
    - You hold so much in reserve, for the next few years to see how they do
    - Conceptually, this is an investment decision even if it is a purchase
- New DAC companies with new technology, that look really different than the current tech, are super expensive right out of the gate but curves could look super good
- Net yet optimizing on price per ton because of this