Where Do Greenhouse Gas Emissions Come From, and What Does That Mean for Investors?

Greenhouse gas emissions are highly concentrated in a few key sectors in investor portfolios; the publicly traded firms in these sectors alone are responsible for about 60% of all global emissions. Investors thinking through climate risks, climate opportunities, and net zero alignment should focus on these sectors.

OCTOBER 27, 2022

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Investors globally are increasingly prioritizing understanding their exposure to climate change: to manage risk, to take advantage of opportunities, and/or to align their investments with achieving net zero climate goals. To understand any of these perspectives with regard to your portfolio, the first question to answer is **how the global problem of climate change intersects with the assets that investors hold**. In this report, we focus on public equities because this asset class represents the largest portfolio allocation for most investors and because these publicly traded companies account for the majority of global emissions.

Examining this question, we see that **greenhouse gas emissions are highly concentrated in a few key sectors in investor portfolios**. By our estimates, the publicly traded firms in 11 key emissions-intensive sectors, accounting for about 30% of public equity market capitalization, are responsible for about 90% of public company emissions and about 60% of all global emissions. In other words, they account for a huge part of the global climate change challenge, and global decarbonization goals cannot be met without reducing emissions in these sectors (or replacing these companies with cleaner competitors).

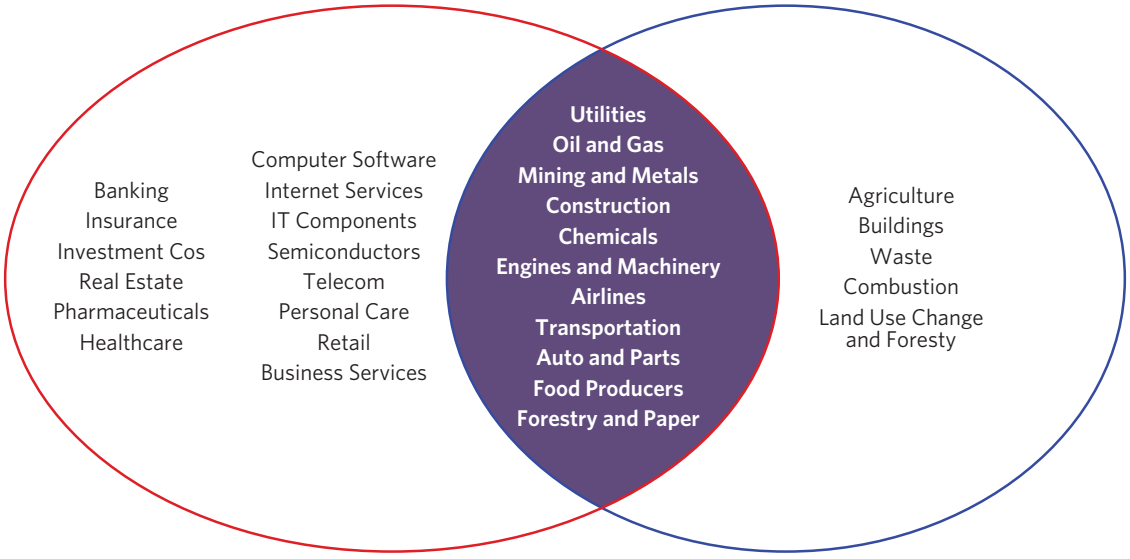
Companies in these sectors—with emissions-intensive operations and/or emissions-intensive products—are most vulnerable to and at risk from the transition to a low-carbon economy via aggressive policy moves (such as carbon taxes, product sales restrictions, or energy rations), competitive pressures from disruptive, cleaner new companies, or technological breakthroughs that undermine existing emissions-intensive business models. Of course, the transition could go slower or faster relative to what markets are already discounting, which could benefit or hurt these sectors. Investors can reduce or eliminate their exposures to these emissions-intensive sectors, but by doing so they remove important parts of the economy from their asset allocations and concentrate their portfolios in companies that are not important players in the decarbonization of the economy.

There is an important role for investors to play in these emissions-intensive sectors. Movement by these sectors to reduce carbon intensity could have the largest impact on decarbonization, and access to capital is critical for them. In our next research piece on this topic, we will share on our thoughts on how investors with net zero goals can approach investing in these sectors.

How the Global Problem of Climate Change Intersects with Publicly Traded Equities

The Venn diagram below reflects where the global problem of climate change (blue circle) intersects with publicly traded equities (red circle). Global greenhouse gas emissions make up more than 50 billion tonnes (Gt) annually in CO2 equivalents, but many publicly traded companies have relatively little to do with the global emissions problem; their business models are such that they are low emitters today or have limited control over their emissions (e.g., they have limited control over how the electricity that heats their buildings is generated). **About 90% of all public company emissions are concentrated in just 11 key emissions-intensive sectors, and we estimate that these companies make up a significant share of the global climate problem—they are responsible for about 60% of all global emissions.**[1]

The most emissions-intensive publicly traded companies (A x B) represent about 30% of market cap, 90% of corporate emissions, and 60% of global emissions

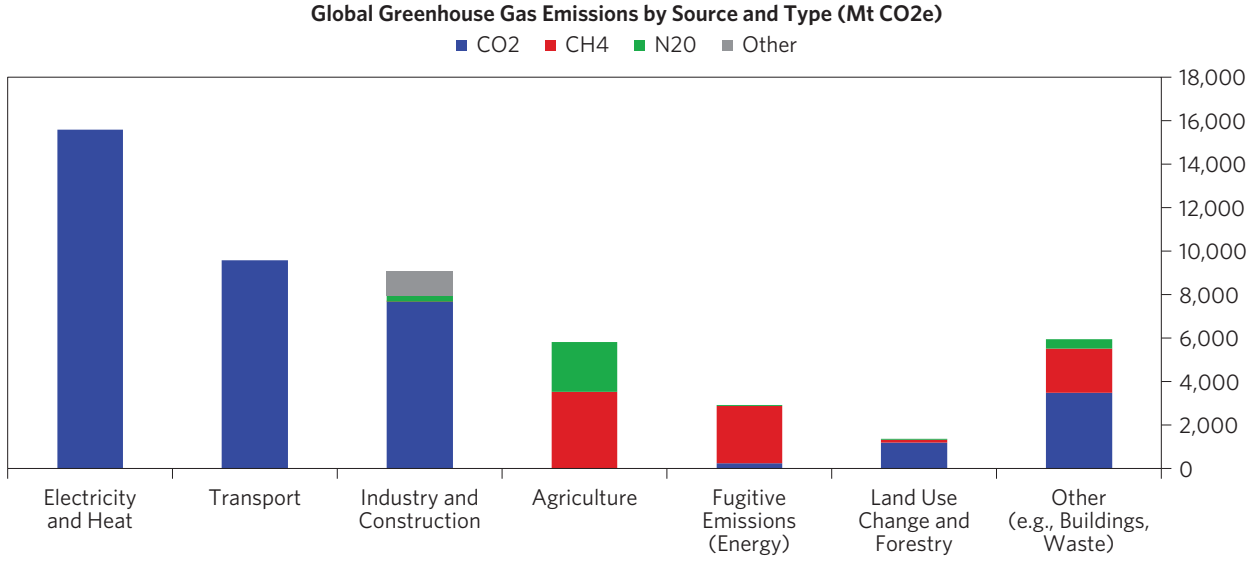


Publicly Traded Companies (A)
$120 trillion in public equity market cap

Major Sources of Global Emissions (B)
~50 Gt CO2e in GHG emissions

[1] There is imprecision inherent in this analytical exercise. Our work is designed to give an indicative top-down sense of the distribution of carbon across public companies. Carbon emissions and decarbonization pathways within any of these industries are complex topics. See discussion of each of these sectors in the Appendix.

Below, we show the breakdown of the sources of greenhouse gas emissions. Global emissions by and large come from electricity and heat generation, transportation, industrial activity and construction, agriculture, and buildings. Carbon dioxide accounts for the majority of global emissions, although methane (CH4) is a big component of emissions from agriculture, fugitive emissions from energy, and waste.



To estimate the share of total emissions attributable to public companies in emissions-intensive sectors, we aggregate emissions bottom-up across public companies in these sectors and reconcile these sums relative to the top-down picture of emissions shown above. We use reported carbon data wherever possible, estimate where there are gaps,[2] and adjust for double counting of emissions across companies and categories.[3] We also compare our findings against quality work done by a variety of sources such as the Mission Possible Partnership, the Institutional Investors Group on Climate Change, the Glasgow Financial Alliance for Net Zero, Speed and Scale, Project Drawdown, and the Transition Pathway Initiative.

We discuss our estimation methodology and include a more detailed write-up of each category in the Appendix. Here is how the 60% of global emissions covered by these companies breaks down:

- **About 30% of global emissions are created through the operations of publicly traded firms in these sectors—i.e., what is referred to as scope 1 and 2 emissions.**[4] This includes utilities that burn coal or natural gas for electricity, oil companies that have fugitive emissions in the process of extracting oil, and industrial firms that emit greenhouse gases as part of their production of chemicals or mining for metals, for example.
- **An additional 30% of global emissions are created through the upstream or downstream supply chains of publicly traded firms in these sectors—i.e., what is referred to as scope 3 emissions.** This includes emissions that are not directly generated by public companies but that they retain a significant degree of control over. For example, the choice by auto manufacturers of whether to produce electric vehicles or internal-combustion-engine vehicles will affect individuals' ability to get around emission-free. When attributing scope 3 emissions, it is also important to avoid double counting—for example, we attribute the emissions from individuals driving cars to the auto manufacturer that produced the car, but not the metals producer that refined the steel.
- **Still, even within these 11 concentrated sectors, there are large differences in public companies' control over their current emissions and the available forward paths to decarbonize.** For example, auto manufacturers have a clear pathway to reduce their downstream emissions by switching their products to electric vehicles, supported by rapid progress in EV technology and manufacturing capabilities, whereas food producers have a more limited ability to catalyze the shift toward plant-based foods without supportive changes in consumer preference. Utilities can switch from coal and other emissions-intensive fuels to several renewable energy technologies (e.g., solar, wind). Many industrials, in contrast, are in earlier stages of developing practical options to reduce emissions on important production processes like those for cement, steel, and ammonia (where the investments they make will likely determine whether new technologies develop and scale to enable the decarbonization of such processes).

[2] Because of gaps in the quality and availability of corporate carbon reporting (especially around scope 3), missing data for scopes 1, 2, and 3 was estimated based on the median carbon intensity of reporting companies. For scope 3, estimates were calculated for each of the 15 upstream/downstream scope 3 categories described in the Greenhouse Gas Protocol and aggregated across different sector groupings to control for the low sample size. For food producers, we referenced bottom-up research from the IATP in building our estimates.

[3] To reduce double counting across scope 3, we looked specifically at upstream/downstream emissions that were unlikely to be included in our other categories. For example, we only consider downstream scope 3 from autos as part of their contribution to global emissions, as much of their upstream scope 3 is already covered by scope 1 and 2 emissions from other key sectors, such as mining and metals or engines and machinery.

[4] Scope 1 emissions are direct greenhouse gas emissions that occur from sources that are controlled or owned by an organization. Scope 2 emissions are indirect greenhouse gas emissions associated with the purchase of electricity, steam, heat, or cooling.

The table below gives more color on each of these emissions-intensive sectors. We account for about 25 Gt (~50%) of all global emissions based on reported and estimated emissions. Based on our research, we hypothesize that another ~5 Gt (~10%) is additionally attributable to these sectors due to systematic underreporting (especially in scope 3 emissions from food producers and autos) or conservative accounting choices in this analysis (for example, in attributing industrial or cross-cutting emissions).[5]

	Total	Electricity and Heat	Transport	Industry and Construction	Agriculture	Fugitive Emissions (Energy)	Land Use Change and Forestry	Other (e.g., Buildings, Waste)
Key Sectors		**Utilities**	**Airlines, Transportation, Auto and Parts**	**Mining, Construction, Chemicals, Engines**	**Food Producers**	**Oil and Gas**	**Forestry and Paper**	**Cross-cutting**
Total Emissions (Gt CO2e)	50.3	15.6	9.6	9.1	5.8	2.9	1.4	5.9
Associated with Key Sectors Est (Gt CO2e)	24.1	9.0	6.4	4.9	1.6	1.9	0.3	—
of Which Scope 1 & 2 (Gt CO2e)	13.2	5.2	0.9	4.9	0.1	1.9	0.2	—
of Which Scope 3 (Gt CO2e)	11.0	3.8	5.5	—	1.5	Cross-cutting	0.2	—
% Associated with Key Sectors Est	48%	58%	67%	54%	28%	64%	24%	—
Relevant Scope 1 & 2 from Key Sectors (Gt CO2e)	13.2	5.2	0.9	4.9	0.1	1.9	0.2	—
% Relevant Scope 1 & 2 from Key Sectors	26%	33%	9%	54%	2%	64%	12%	—
Do Companies Have Control?	—	Yes	Somewhat	Somewhat	Somewhat	Yes	No	—
What Are Some Ways Companies Can Reduce These Emissions?	—	Switch from fossil fuels to renewable energy, etc.	Switch to biofuel flights (for airlines), etc.	Improve energy efficiency and waste management, etc.	Utilize precision agriculture, etc.	Better methane leak management, etc.	—	—
How Feasible Is This Path?	—	Clear pathway	Significant challenges	Some challenges	Some challenges	Clear pathway	—	—
Relevant Scope 3 from Key Sectors Est (Gt CO2e)	11.0	3.8	5.5	—	1.5	Cross-cutting	0.2	—
% Relevant Scope 3 from Key Sectors Est	22%	24%	57%	—	26%	Extremely high	12%	—
Do Companies Have Control?	—	Yes	Yes	—	Somewhat	Yes	No	—
What Are Some Ways Companies Can Reduce These Emissions?	—	Switch from fossil fuels to renewable energy	Switch from ICEs to EVs (for autos)	—	Switch from meat to plant-based foods	Switch from fossil fuels to renewable energy	—	—
How Feasible Is This Path?	—	Clear pathway	Clear pathway	—	Some challenges	Clear pathway	—	—

[5] We estimate around 10-15 Gt of the remaining emissions are attributable to state-owned or privately owned companies, and that 5-10 Gt are attributable to a mix of individuals (e.g., residential buildings, farming), other publicly traded sectors (e.g., semiconductors, healthcare), and natural causes (e.g., wildfires).

Investors Thinking Through Climate Risks, Climate Opportunities, and Net Zero Alignment Should Focus on These Sectors

Companies in these sectors—with emissions-intensive operations and/or emissions-intensive products—are most vulnerable to and at risk from the transition to a low-carbon economy if aggressive policy moves (such as carbon taxes, product sales restrictions, or energy rations), competitive pressures from disruptive, cleaner new companies, or technological breakthroughs that undermine existing emissions-intensive business models accelerate.

While many publicly traded companies have put out plans to reduce emissions, very few companies in these sectors have comprehensive, credible plans; we estimate that only 20–25% of the emissions of public companies in these sectors are covered by reduction targets. An even smaller share have plans that are validated by the Science-Based Targets initiative (SBTi).[6,7] Thus far, most of the forward-looking emissions targets set by companies are in the less carbon-intensive sectors, which will play a less significant role in the climate transition.

High emissions-to-market cap

Majority of global emissions concentrated in a few key sectors

	Scope 1, 2 & 3 Emissions (Gt CO2e)	Market Cap (USD, Tln)	Scope 1 & 2 Emissions (Gt CO2e)	% Covered by Company Targets	% Covered by Science-Based Targets	Scope 3 Emissions (Gt CO2e)
Oil and Gas	31.2	8.1	3.1	27%	—	28.1
Utilities	9.9	3.7	5.2	26%	8%	4.7
Auto and Parts	7.9	3.4	0.1	37%	21%	7.7
Mining and Metals	6.6	3.1	2.7	19%	4%	3.9
Engines and Machinery	9.1	4.4	0.1	24%	11%	8.9
Construction	3.8	2.3	2.1	26%	22%	1.8
Chemicals	3.5	3.2	1.0	22%	5%	2.5
Airlines	0.6	0.6	0.5	30%	5%	0.1
Food Producers	1.9	2.4	0.2	26%	18%	1.7
Forestry and Paper	1.9	0.5	0.2	34%	22%	1.7
Food and Drug Retailers	2.4	0.9	0.1	35%	19%	2.3
Semiconductors	1.0	4.7	0.1	31%	8%	0.9
IT Components	0.6	2.3	0.1	28%	16%	0.5
Transportation	0.7	2.4	0.4	43%	11%	0.3
Retailers	0.9	3.2	0.2	43%	18%	0.7
Personal Care	0.3	1.6	0.0	72%	70%	0.3
Real Estate	0.6	4.1	0.1	33%	12%	0.4
IT Manufacturers	0.7	4.2	0.0	34%	33%	0.7
Beverages	0.2	2.5	0.0	58%	51%	0.2
Business Services	0.2	3.3	0.1	35%	17%	0.1
Internet Services	0.1	3.5	0.0	79%	1%	0.1
Healthcare	0.5	3.6	0.0	17%	7%	0.5
Pharmaceuticals	0.2	4.4	0.0	50%	40%	0.2
Investment Companies	0.4	3.6	0.0	59%	2%	0.3
Computer Software	0.1	5.6	0.0	73%	28%	0.0
Banks	0.8	11.0	0.0	28%	1%	0.8

Some sectors with a larger contribution to scope 1 and 2, some sectors with a larger contribution to scope 3

Sectors with a high proportion of emissions-reduction targets tend to be lower-emitting

Low emissions-to-market cap

[6] The Science-Based Targets initiative is a global partnership of stakeholders, including the UN Global Compact and the Carbon Disclosure Project, that provides independent validation of emissions-reduction targets in line with climate science.

[7] Note that specific SBTi guidance is unavailable for certain sectors (e.g., oil and gas) and is in the process of being refined for others (e.g., auto manufacturers)

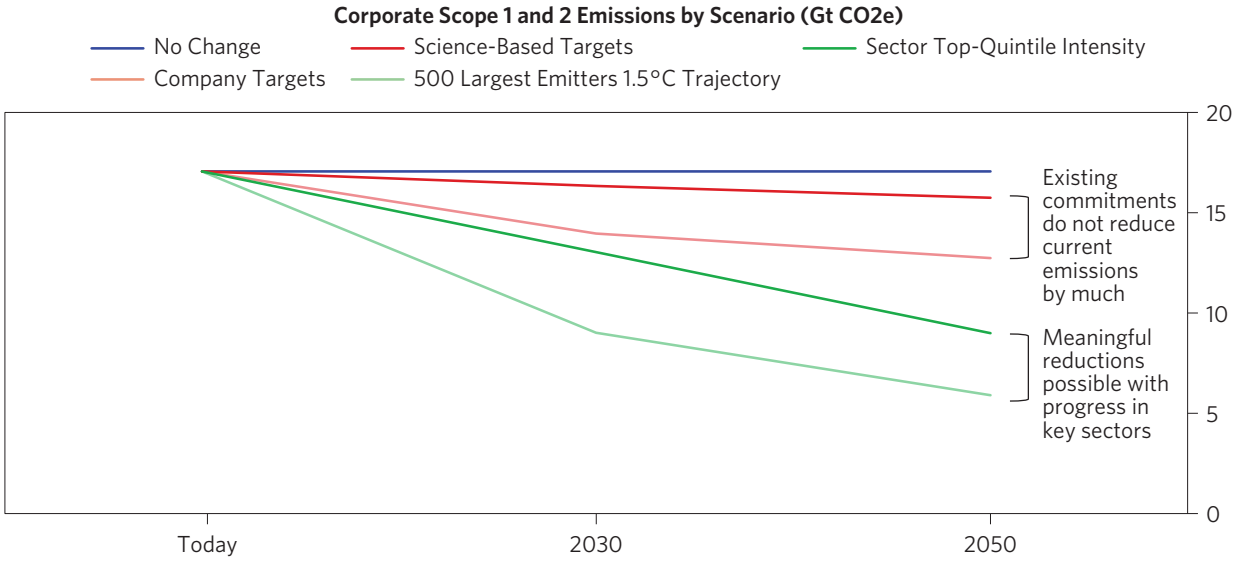
These emissions-intensive sectors are most directly impacted by the pace and aggressiveness of global policy moves to meet climate change goals. For example, assuming no pass-through of costs, these most emissionsintensive sectors would face an average 50% structural reduction in earnings under a $100 per tonne carbon price policy regime compared to an average 3% hit to earnings for all other sectors.[8] This specific policy lever is unlikely to transpire in the near term, but the stark contrast highlights the implications of carbon intensity for these companies.

The impacts on any company will depend on how rapidly the world transitions—policy moves to encourage the transition could go slower or faster relative to what markets are already discounting—as well as what mechanisms are used to incentivize the transition. As we've discussed, there are multiple mechanisms for climate action to accelerate, each of which will affect companies and economies differently. We've seen policy actions that are focused on incentivizing carbon reductions, which can be supportive for emissions-intensive firms (e.g., the Inflation Reduction Act supporting utilities and oil companies with green incentives), as well as policy actions that are more punitive, such as taxing emissions or banning emissions-intensive products (e.g., phasing out internal combustion engines for car companies). As shown below, each of the emissions-intensive sectors is already seeing policy action intended to curb emissions that hits their operations and profitability.

Sector	Incentives	Examples
Utilities	**Incentives** for renewable energy	**USA:** More than $200 billion in clean energy tax credits and incentives as part of the Inflation Reduction Act
	Disincentives for fossil fuels	**Multiple (including Canada, Poland):** Commitment during COP26 to phase out coal-fired power plants by 2040
Oil/Gas	**Disincentives** for oil/gas	**Denmark:** Commitment to end oil and gas exploration in the North Sea by 2050 at an estimated cost of around $2 billion
		USA: Tighter regulation of methane leaks via methane emissions charge of up to $1,500/tonne as part of the Inflation Reduction Act
Construction	**Incentives** for green materials	**USA:** Federal Buy Clean Initiative to support the procurement of low-carbon variants of construction materials such as steel and concrete
	Disincentives for heavy industry	**China:** Ban on heavy industrial projects (e.g., cement, steel) in already polluted regions or near river basins and urban areas
Auto and Parts	**Incentives** for electric vehicles	**USA:** Extension of tax credits (up to $7,500) for EV purchases as part of the Inflation Reduction Act
		China: Electric vehicle credit system (similar to a compliance-based carbon market) where EV manufacturers can sell excess credits to ICE manufacturers
	Disincentives for ICE vehicles	**Multiple (including EU, Canada, UK):** Zero emissions mandate on new vehicles sales beginning as early as 2030
		USA: Increased penalties for vehicles that fail to meet fuel economy standards
Airlines	**Disincentives** for airlines	**France:** Ban on short-haul flights with alternative train routes of less than 2.5 hours
Food Producers	**Incentives** for plant-based foods	**Canada:** $100 million government investment in plant-based food plant using domestically sourced peas and canola seed
	Disincentives for livestock	**New Zealand:** Proposal to tax biogenic methane emissions from livestock by 2025
		Netherlands: Plan to reduce the number of cows, pigs, and chickens by a third
Forestry and Paper	**Disincentives** for deforestation	**UK:** Ban on sale of products with evidence of large-scale deforestation in their supply chains

[8] The $100 per tonne carbon price is a rough estimate of the minimum level needed for a meaningful carbon transition. This is a simple illustration of the transition risks for these sectors. Many of these companies would in practice be able to offset some of their cost increases by passing them on to consumers (among other ways to mitigate the impact). Given the current focus on energy security and massive increases in energy prices, carbon prices seem like a policy lever less likely to garner the necessary political will to enact at the moment, but we think this analysis gives a reasonable picture of the first-order transition risks that these sectors would face and the large variation in transition risk across sectors.

While investors could reduce or eliminate their exposures to these emissions-intensive sectors, in doing so they would remove important parts of the economy from their asset allocations and concentrate their portfolios in companies that are not important players in the decarbonization of the economy. Instead, we believe there is an important role for investors to play in these emissions-intensive sectors, as movement by these sectors to reduce carbon intensity can have the largest impact on decarbonization. As shown below, if all companies reduced carbon intensity to match their top-quintile industry peers, corporate scope 1 and 2 emissions would fall by about 45–50%. If just the largest 500 emitters (nearly all of whom are in these sectors) were on a 1.5°C trajectory, corporate scope 1 and 2 emissions would fall by around 65%.



Additionally, investors play an important role since they ultimately set the price of capital—and access to capital is critical in these sectors. The Glasgow Financial Alliance for Net Zero estimates that more than $30 trillion in investments (~4% global GDP annually) will be needed to finance the climate transition by 2030. This represents a meaningful increase in investment from current levels of around $10 trillion. Much of the necessary investment will need to occur in these sectors, at existing publicly traded companies, or at competitors that will displace them. Note that many of the financing needs are in Asia and other regions outside of the US and Europe, where most investors are concentrated.

The general road map for the technologies and innovations that will help the economy move toward net zero emissions is increasingly well laid out, giving many companies a clear pathway if they choose it. Identifying and investing in credible transition pathways in these high-emitting sectors can be a way to support decarbonization goals, reduce transition risk, or identify opportunities from the transition.

Below, we reference the excellent work from Project Drawdown, which describes "plausible and economically realistic" transition pathways and their potential emissions-reduction contributions. **For public companies in these sectors, these transition solutions are already realistic investment options.** In addition to the emissions-reduction potential, we also include the share of emissions attributable to public companies in the emissions-intensive sectors. By and large, public market investors are more heavily exposed to the industries in the top half of the table (i.e., electricity, industry, transportation, oil and gas), while much of the emissions from industries in the bottom half tend to be cross-cutting or in private markets.

	% Emissions Attributable to Key Sectors	Solution Group	Ann Reduction (Gt CO2e)	Examples
Transport	67%	Alternative Transportation	1.4	Public transport, cycling
		Vehicle Efficiency	0.9	Efficient trucks, efficient aviation
		Electric Vehicles	0.6	Electric cars, electric trains
		Total	**2.9**	
Fugitive Emissions	65%	Methane Management	0.3	Methane capture, methane digestors
		Total	**0.3**	
Electricity and Heat	60%	Renewable Energy	12.4	Solar power, wind power
		Energy Management	0.2	Energy storage, flexible grids
		Total	**12.6**	
Industry and Construction	54%	Refrigerants	3.5	Alternative refrigerants
		Alternative Products	0.6	Alternative cement, bioplastics
		Total	**4.1**	
Agriculture	28%	Dietary Changes	3.4	Plant-based foods
		Food Waste	3.4	Reduced food waste
		Livestock Management	3.2	Manure management, managed grazing
		Crop Management	2.4	Improved irrigation, rice production
		Total	**12.4**	
Land Use and Forestry	24%	Forest Management	4.5	Forest protection, forest restoration
		Land Management	4.1	Grassland protection, farmland restoration
		Carbon Sequestration	2.5	Tree intercropping, seaweed farming
		Marine Management	0.4	Seafloor protection, wetlands restoration
		Total	**11.5**	
Other (e.g., Buildings, Waste)	—	Building Management	3.4	Insulation, LED lighting
		Clean Cooking	2.9	Clean cookstoves, biogas
		Recycling and Waste	1.0	Recycled metals, recycled plastics
		Total	**7.3**	

In the future, we will share our thoughts on how investors with net zero goals can approach investing in these sectors.

Appendix: Penciling Out an Attribution of Emissions by Sector

Our work is designed to give an indicative top-down sense of the distribution of carbon across public companies, but there is imprecision inherent in this analytical exercise. Because of gaps in the quality and availability of corporate carbon reporting (especially around scope 3), missing data for scopes 1, 2, and 3 was estimated based on the median carbon intensity of reporting companies. For scope 3, estimates were calculated for each of the 15 upstream/downstream scope 3 categories described in the Greenhouse Gas Protocol and aggregated across different sector groupings to control for the low sample size. To reduce double counting across scope 3, we looked specifically at upstream/downstream emissions that were unlikely to be included in our other categories. For example, we only consider downstream scope 3 from autos as part of their contribution to global emissions, as much of their upstream scope 3 is already covered by scope 1 and 2 emissions from other key sectors, such as mining and metals or engines and machinery.

Below, we discuss each of the categories in more detail.

Key Sectors	Total	Electricity and Heat Utilities	Transport Airlines, Transportation, Auto and Parts	Industry and Construction Mining, Construction, Chemicals, Engines	Agriculture Food Producers	Fugitive Emissions (Energy) Oil and Gas	Land Use Change and Forestry Forestry and Paper	Other (e.g., Buildings, Waste) Cross-cutting
Total Emissions (Gt CO2e)	50.3	15.6	9.6	9.1	5.8	2.9	1.4	5.9
Associated with Key Sectors Est (Gt CO2e)	24.1	9.0	6.4	4.9	1.6	1.9	0.3	—
of Which Scope 1 & 2 (Gt CO2e)	13.2	5.2	0.9	4.9	0.1	1.9	0.2	—
of Which Scope 3 (Gt CO2e)	11.0	3.8	5.5	—	1.5	Cross-cutting	0.2	—
% Associated with Key Sectors Est	48%	58%	67%	54%	28%	64%	24%	—
Relevant Scope 1 & 2 from Key Sectors (Gt CO2e)	13.2	5.2	0.9	4.9	0.1	1.9	0.2	—
% Relevant Scope 1 & 2 from Key Sectors	26%	33%	9%	54%	2%	64%	12%	—
Do Companies Have Control?	—	Yes	Somewhat	Somewhat	Somewhat	Yes	No	—
What Are Some Ways Companies Can Reduce These Emissions?	—	Switch from fossil fuels to renewable energy, etc.	Switch to biofuel flights (for airlines), etc.	Improve energy efficiency and waste management, etc.	Utilize precision agriculture, etc.	Better methane leak management, etc.	—	—
How Feasible Is This Path?	—	Clear pathway	Significant challenges	Some challenges	Some challenges	Clear pathway	—	—
Relevant Scope 3 from Key Sectors Est (Gt CO2e)	11.0	3.8	5.5	—	1.5	Cross-cutting	0.2	—
% Relevant Scope 3 from Key Sectors Est	22%	24%	57%	—	26%	Extremely high	12%	—
Do Companies Have Control?	—	Yes	Yes	—	Somewhat	Yes	No	—
What Are Some Ways Companies Can Reduce These Emissions?	—	Switch from fossil fuels to renewable energy	Switch from ICEs to EVs (for autos)	—	Switch from meat to plant-based foods	Switch from fossil fuels to renewable energy	—	—
How Feasible Is This Path?	—	Clear pathway	Clear pathway	—	Some challenges	Clear pathway	—	—

Working backwards, we can also develop a rough accounting for the remaining ~25 Gt of emissions. Of the remaining 25 Gt of emissions, we estimate that another ~5 Gt is possibly attributable to these sectors due to underreporting (especially in scope 3 emissions from food producers and autos) or conservative accounting choices in this analysis (for example, in attributing industrial or cross-cutting emissions).

We estimate that about 10-15 Gt of emissions comes from state-owned or privately owned companies and that the remaining 5-10 Gt are attributable to a mix of individuals (e.g., residential buildings, farming), other publicly traded sectors (e.g., semiconductors, healthcare), and natural causes (e.g., wildfires).

Details by Category

Electricity and heat: We estimate that 58% of all emissions from electricity and heat are generated by publicly traded utilities. Aggregating scope 1 and 2 emissions (e.g., power generation) across publicly listed utilities amounts to 5.2 Gt CO2e, which is around 33% of emissions for the category. If we factor in downstream scope 3 emissions (e.g., use of electricity by end-users), this number rises to as much as 9.0 Gt CO2e. Note that we only include the subset of upstream scope 3 emissions (e.g., emissions produced in the extraction of natural gas) that is not already captured in the fugitive emissions from the energy category to minimize double counting. By transitioning from coal or gas to renewable-powered energy grids, publicly listed utilities play an important role in bringing down emissions for electricity and heat, thus supporting the net zero transition. These companies are by and large in control of their emissions across scopes 1, 2, and 3, there are relatively clear transition pathways, and, for many electricity producers, these shifts are already underway.

Transport: We estimate that 67% of all emissions from transportation are generated by publicly traded airlines, autos, and transportation companies. Scope 1 and 2 emissions (e.g., direct corporate activity like flying airplanes or building cars) from these sectors amount to about 0.9 Gt CO2e, or 9% of total emissions from transport. However, the majority of emissions—around 5.5 Gt or 57% of emissions for the category—comes from downstream scope 3, in particular the use of vehicles by individuals. Because of the overlap in supply chains with other sectors within the category, we did not include transportation services in our aggregation of scope 3 emissions. In addition, the exact accounting of emissions from the use of passenger vehicles is imprecise and depends on a number of factors such as the vehicle's lifespan on the road. As such, we expect this number to represent a minimum for the category rather than a precise estimate. Nonetheless, it is important to note that auto manufacturers can control the extent of their scope 3 emissions depending on whether they choose to produce internal-combustion-engine vehicles or electric vehicles. Reducing scope 3 emissions via a transition to electric vehicles is underway, while some pathways for scope 1 and 2 emissions reductions (e.g., airline biofuel) are not yet available with current technology.

Industry and construction: We estimate that at least 54% of all emissions from industry and construction are generated by publicly traded high-emitting industrials in the mining and metals, construction, chemicals, and engines and machinery sectors. Scope 1 and 2 emissions from these sectors amount to 4.9 Gt CO2e, or 54% of emissions from industry and construction. On the whole, most large-scale industrial activity takes place in public markets, which means companies can reduce their scope 1 and 2 emissions via changes in business behavior (e.g., energy efficiency, waste management), many of which are already underway, although some products/services changes may be harder (e.g., green cement). While scope 3 emissions from the sector are sizable (because industrial goods are so essential to economic activity), they are largely attributable to other categories (e.g., downstream scope 3 from engines and machinery would be included in emissions from transportation) or other parts of the same category (e.g., downstream scope 3 from metals and mining would be included in scope 1 and 2 of construction). These scope 3 emissions are also harder for companies to control, as the uses of industrial goods are so varied (e.g., a copper producer cannot specify whether its products are used for climate-aligned purposes, such as renewable-energy technology, or non-climate-aligned purposes, such as internal combustion engines).

Agriculture: While agriculture is a large share of global emissions, we estimate that only about 28% of emissions from agriculture are generated by publicly traded food producers. Similar to transportation, publicly traded food producers' scope 1 and 2 emissions (e.g., from food processing), are relatively small, at 0.1 Gt CO2e. Most of their carbon contribution comes from upstream scope 3 from livestock, which amounts to 1.5 Gt CO2e, or 26%, of emissions from agriculture. To address criticism of scope 3 underreporting by food producers, where available we use external estimates from the IATP (which are based on a bottom-up life-cycle analysis of the quantity of livestock that various food producers report as inputs into their products), but this number is still likely to be a lower bound of scope 3 emissions from the sector. While food producers have some control over these scope 3 emissions depending on whether they choose to produce emissions-intensive foods (e.g., meat), this choice depends in large part on other factors such as consumer preferences, which limits the degree of control companies—and hence public market investors—have over the sector's transition pathway. In addition, many of the major players in this sector (e.g., Cargill, Louis Dreyfus) continue to be privately owned. Reducing the carbon intensity of agriculture is one of the key challenging questions ahead.

Fugitive emissions (energy): We estimate that 65% of fugitive emissions from energy production are generated by oil and gas companies that are present in public markets (including those with strong state ties such as Saudi Aramco or PetroChina). Fugitive emissions take place primarily in the extraction and refining phases of oil and gas activities and account for 1.9 Gt or 65% of emissions from the category. The remainder of oil and gas direct emissions is apportioned to upstream scope 3 from electricity and heat. In terms of fugitive emissions, these companies have some degree of control, as technologies to reduce these emissions currently exist (e.g., better methane leak management). However, oil and gas companies have a large impact via their scope 3 emissions, which are spread across multiple other categories as scope 1 and 2 emissions for electricity and heat, transportation, fuel combustion, etc., making oil and gas one of the most important transition-related sectors. For reference, total energy-related CO2 emissions (including those outside of public markets) amount to 30-35 Gt CO2e, or more than 60% of all global emissions. The shift from fossil fuels to renewable energy is thus a massively challenging, capital-intensive transition requiring a turnover of global energy systems and supply chains.

Land use change and forestry: Most of the activity in this category occurs outside of public markets, although there is some relatively small contribution from forestry and paper companies (0.3 Gt CO2e across scope 1 and 2 and upstream scope 3, or 24% of emissions from land use change and forestry). Most of the emissions associated with this sector come from deforestation for agriculture or commodity production or as a result of wildfires.

Other (e.g., buildings, waste): There is a sizable share of emissions (about 10% of all emissions, or 5.9 Gt) that are largely not directly related to the most energy-intensive sectors but are cross-cutting, such as real estate, space and water heating, and waste. Nearly all public companies (and individuals and private companies)—not just those in these emissions-intensive industries—will need to address the emissions profile of their real estate, space and water, and waste footprint. For the purpose of this exercise, we did not attribute any of these emissions to the key emitting sectors discussed above.

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