

FAILURE
TO IMPACT:
ARE ESG FUNDS
DELIVERING
ON INVESTORS'
AMBITIONS?



MASSIFCAPITAL

NOTE: ESG stands for Environmental, Social and Governance; the acronym is most commonly applied to various types of investment products that prioritize, in some way, the assessment of portfolio composition or companies based on how a portfolio, or company rank relative to an organization determined ESG standard. This paper focuses on questions explicitly related to the Environment component of those strategies. This should not be interpreted as meaning that the S and G are unimportant, it is merely a question of the author's choice of focus.

Introduction

The momentum behind ESG investing has grown enormously in recent years. Despite the growth, the ESG investment universe remains challenging to have a productive conversation about as environmental, social, and governance concerns are diverse enough to allow for almost any issue to be subsumed by the acronym. Furthermore, like so many in financial marketing terms, ESG lacks any descriptive quality that enables an investor to understand how a strategy is built around the individual variables. Despite the numerous shortcomings that arise from such a poorly constructed acronym, environmental, social, and governance variables are critical in evaluating a business's value. The materiality of environmental, social, and governance issues to a company is contextual though, and difficult, if not impossible, to evaluate in the often rote quantitatively driven way so common to a diverse set of investment strategies currently being marketed to investors under the ESG moniker.

Environmental issues, in particular, are highly contextual. That some firms pollute more than others is a mostly meaningless observation. Yet, the unsophisticated ranking of firms based on environmental footprint is just that, an observation that some firms pollute more than others. Without an analysis of a business's economic significance or criticality to the broader economy, its environmental impact is without an essential interpretive context. That firms such as Apple and Microsoft, two of the most widely held businesses in ESG portfolios, pollute less than copper miners and aluminum producers is a meaningless observation in the context of a desire to invest for impact. That firms like Apple and Microsoft depend on copper miners and aluminum producers for their businesses means that the question investors should be asking is how one balances environmental impact and economic criticality, not simply how one limits a portfolio's overall environmental impact.

According to [The Forum for Sustainable and Responsible Investors](#), climate change is the number one issue for asset managers with ESG mandates. A 2019 Morgan Stanley report, detailing the interests of ESG investors in the United States with more than \$100,000 in investable assets, further identified climate change and the environment as the principal motivation behind ESG allocations. The survey also found that 71% of investors believed their investments could influence the amount of climate change caused by human activities and that the desire for their investments to have an impact was the core motivation for allocating capital to ESG investment products.

When considered alongside the spread of divestment actions by institutional investors, and numerous other qualitative items, such as the Larry Fink's most recent



Letter to CEOs, it is reasonable to conclude that the environment, and specifically slowing climate change, are two key motivations driving ESG investment products.

The primary motivation for writing this paper is to highlight that the trend toward passive ESG vehicles is likely only to exacerbate the environmental analysis that produces results directly counter to the stated objectives and intent of most investors.

That most products marketed to such investors rank environmental impact without consideration given to context should thus be a cause for concern. That investors are increasingly allocating their ESG dollars to ESG ETFs, which as a result of their construction process do nothing more than arbitrarily rank companies, should be of even more concern. **The primary motivation for writing this paper is to highlight that the trend toward passive ESG vehicles is likely only to exacerbate the environmental analysis that produces results directly counter to the stated objectives and intent of most investors.**

One can think of environmentally concerned portfolios as falling into one of two categories.¹ One category are portfolios constructed to reduce climate-related risk by allocating capital to investments in businesses that rank highly in any of the ESG rankings available to investors.² This approach would include the divestment of steel companies or avoiding business with controversial environmental histories (for example, the bursting of a tailings dam at a mine).³ The vast majority of passive ESG vehicles take this approach.

The alternative is to consider climate change as a problem that can be addressed and invest in companies that will aid or benefit from the transition to a low carbon economy. Of these two approaches, the simplicity and ease with which the first can be executed in an ETF structure has led to its widespread adoption.⁴ Given that ESG ETFs primarily allocate capital to companies that do no harm to the environment but also do not do any good either, such investments are at odds with the stated desire of 71% of ESG investors to have a positive environmental impact.

Investors can thus rightly ask: If my ESG ETF investment produces no positive impact, does it, by dint of directing capital away from firms critical to transitioning the economy to a more sustainable footprint, do more harm than good. Aligning a portfolio with one's values by investing in companies that are not objectionable is fine, if that is your goal. It is, however, very different from investing in companies that will not only survive in an economy transitioning to a low-carbon footprint, but that also enable that transition. **We fear that over time, as ESG ETFs proliferate, a significant opportunity to promote change via smarter capital allocation will be lost in the widespread misallocation of investor capital.**

The Makeup of ESG ETFs

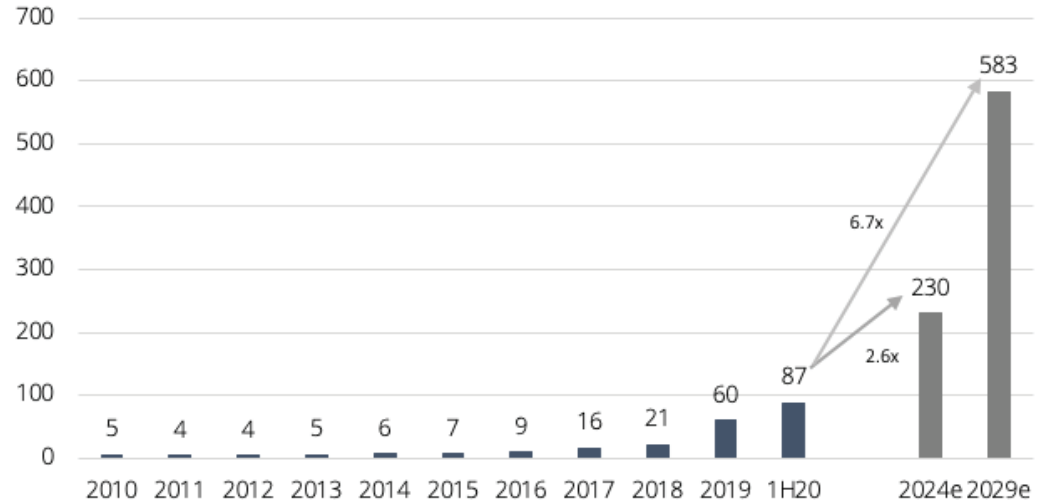
ETFs may soon overtake active management as the dominant method for ESG compliant investing. Flows into ESG ETFs accounted for 22% of total net inflows into ESG funds since January 2019, and ESG ETF AUM has quadrupled over the same period.⁵ Year-to-date (through August), \$29 billion, or 13%, of the broader ETF market has flowed towards ESG strategies. The vast majority has ended up at Blackrock, who controls 45% of the current market-wide ESG ETF AUM. According to the Financial Times, pension funds, mutual funds, and insurance companies with ESG mandates



are currently allocating 21% of their portfolio to passive funds. 45% of respondents to a recent Invesco survey of 1,010 European institutional investors said they planned to increase that amount in the next two years.

It is safe to say that ESG investing has been one of the hottest sectors of 2020, with ETFs playing a leading role.

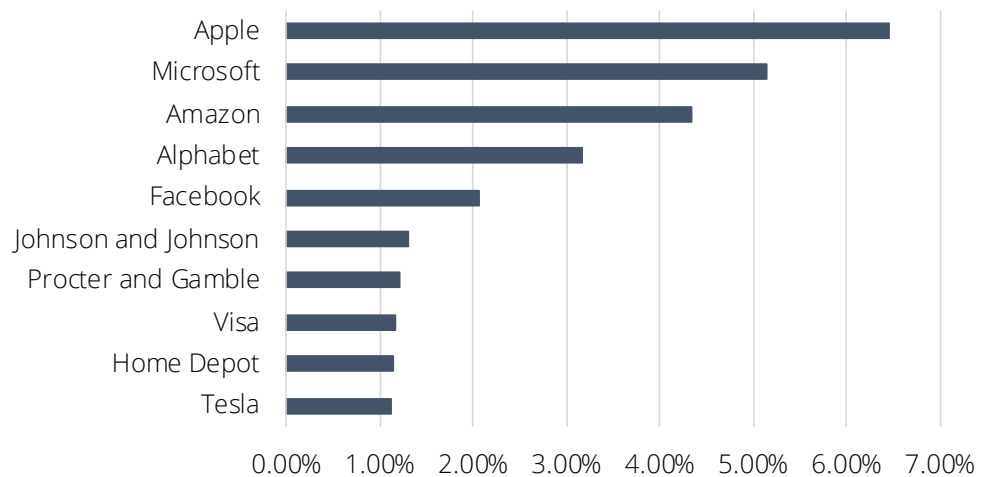
Growth in ESG ETF AUM USD Billions



Source: Massif Capital, Morgan Stanley, Morningstar, Blackrock

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Top Ten Holdings of iShares ESG MSCI ETF by Portfolio Allocation



Source: iShares.com, as of 9/17/2020

For example, take the top 10 holdings of the world’s largest ESG ETF, the iShares ESG MSCI USA ETF, presented in the bar chart above. The top 10 is principally made up of technology companies with a limited environmental footprint that are typically not engaged in activities that could be considered significant for advancing societal decar-



bonization goals. Although Apple's efforts to reduce their carbon footprint are to be applauded, their carbon footprint (scope 1, 2, and 3 emissions) in 2018 was just 25.1 million metric tons of CO2 or 0.5% of all US energy-related CO2 emissions in 2018.⁶ To suggest that Apple has no meaningful impact on climate change in the present, and no significant effect on the future, is not far off the mark. As an ESG ETF's goal is to do no harm, one can rightly say the goal has been accomplished.⁷

The makeup of the iShares ESG USA MSCI portfolio is not an outlier. When we expand our examination to include the top 10 holdings to all ESG ETFs, it produces a similar result, as the chart below demonstrates.⁸

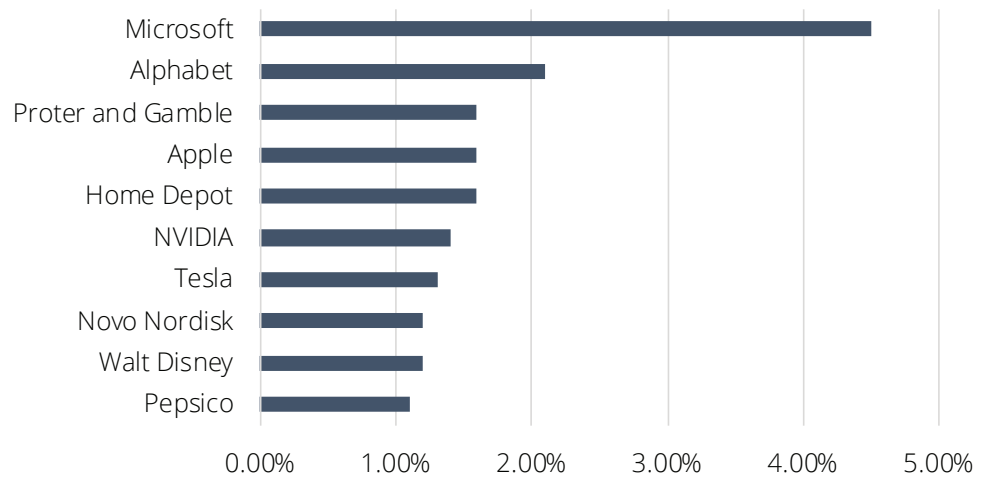
If investors want to make a difference, as they often claim they do, it seems unlikely that this ETF would be a top pick. A dollar invested in these companies is a dollar invested not in decarbonization but rather information technology and social networks.

Passive < Active in Transitioning Sectors

There are two core issues with passive vehicles leading the growth in environmentally conscious investing. The first is that these ETFs are selling differentiation, yet their holdings closely mimic broad market indices in areas of concern for the environmentally-conscious investor. Second, the very nature of passive investment construction obfuscates the opportunity to recognize businesses and markets in the process of producing change.⁹

There are two core issues with passive vehicles leading the growth in environmentally conscious investing.

Top Ten Holdings of all ESG ETFs by Portfolio Allocation



Source: Morgan Stanley

The index upon which the iShares MSCI USA ESG ETF is based is designed "to target companies with positive environmental, social, and governance characteristics while closely representing the risk and return profile of the underlying market."¹⁰ The goal is not to support global decarbonization; the goal is to invest in the market and weight that investment toward firms that have already done an excellent job burnishing their ESG credentials. Supposedly this reduces the climate-related risk.



On the issue of differentiation, ETFs must often prioritize “representing the risk and return profile of the underlying market,” with slight weighting adjustments to reflect whatever named product they are selling. If you invest in the iShares ESG MSCI USA ETF, roughly 2.25% of your investment is allocated to oil and natural gas producers, and your expense ratio is 0.15%. If you invest in the world’s largest ETF, the SPDR S&P 500 ETF, ~ 2.52% of your investment is allocated to a similar group of oil and gas-related businesses, with an expense ratio of 0.09%. Ditto for the Vanguard Total Stock Market ETF (2.42% and 0.03%) and the iShares Core S&P 500 ETF (2.52% and 0.03%).

Although ETFs are increasingly popular among institutional investors, they are designed for retail investors, and we suspect few look closely at the construction methodology of the ETF. Many investors would probably be surprised to find that part of their investment is going to large-cap US oil majors and even more surprised that they could buy roughly the equivalent basket of companies with a non-ESG marketed ETF and approximately the same exposure to oil with 66% lower fees.

The construction of passive vehicles and the reliance on backward-looking ESG scores is also a significant problem. Reliance on historical data is a well-known issue with any forecasting endeavor. Yet, for businesses facing technological, societal, and regulatory pressures to change, as most carbon-intensive and economically critical companies such as aluminum smelters, copper miners, etc. are, the notion that we should rely on historical ESG data is even more problematic.

Take, for example, Air Products Inc (APD), which makes up 0.13% of iShares ESG MSCI USA ETF, an admittedly small allocation. Air Products prides itself on producing “sustainable growth for a sustainable future.” The firm has even been recognized by many ESG ranking firms as a leader in the corporate world of sustainability, winning, for example, the EcoVadis 2020 Gold Metal for CSR Performance.

They are also one of the world’s largest builders and soon to be operators of coal gasification plants in Asia. From 2018 - 2025, APD will triple their CO2 emissions and become one of the top three CO2 emitters in the S&P 500, just behind Exxon Mobil and coal-burning utility Duke Energy.¹¹

How long will it take ESG rankings like those produced by Thomson Reuters, or any number of other organizations to reflect that reality? Thomson Reuters has given APD an ESG score of 7/10, 10 being the highest score, and an environmental sub ranking of 9/10. With its lowly carbon emissions, Apple only scores 7/10 on the environment, and Tesla only 6/10.

A curious investor may look at APD, acknowledge that their CO2 emission profile is growing at an alarming pace, but believe that their leadership in developing and commercializing hydrogen production outweighs its emission profile. That’s a reasonable assertion. The point isn’t that APD has a high emission profile and should not be in a passive ESG product. It is that passive products cannot consider how corporate strategies are changing.



Investment is Superior to Divestment: How We Think about the “E.”

Addressing climate change is either about fundamentally changing how we live our lives as individuals or about businesses fundamentally changing how they address our needs as individuals.

Climate change is not a selective risk. It does not distinguish between polluters and non-polluters. Merely avoiding businesses that do no harm will not reduce the risk associated with climate change’s adverse economic impact. Furthermore, divestment, if successful at scale, is likely counter-productive to decarbonization efforts. Roughly 50% of current global emissions have little, if any, economically viable alternative solutions to-date to decarbonize.¹² These industries, the products of which are all around us, require investment, not divestment. **Addressing climate change is either about fundamentally changing how we live our lives as individuals or about businesses fundamentally changing how they address our needs as individuals.** Of the two, the latter, in our opinion, seems far more likely to succeed.

At issue with ETFs and de-risking strategies more broadly, is that they do not contribute to a solution and, given the systemic nature of climate change, are unlikely to reduce risk. This occurs while depriving businesses that need to change of the stable investor base that would empower management teams to make significant strategic changes necessary to decarbonize. It is thus far more productive, and in keeping with the impact desire of investors, to allocate capital to carbon-intensive businesses that produce critical goods that the economy needs but have not yet figured out how to transition to a low carbon footprint.

While Apple decarbonizing is good, an investment in a steel company that enables management to commit to a decarbonization strategy is far more impactful and meaningful. The judgment calls necessary to make these kinds of investments are not feasible with the context of either an ETF or any strategy for that matter, that simply adjusts allocations based on absolute environmental footprint. With this in mind, we find it helpful to think about businesses as transitioners or enablers.

TRANSITIONERS

Roughly 14% of global greenhouse gas emissions come from the steel and cement industries. Together they have more impact on the environment than automobiles in terms of atmospheric emissions.¹³ **Put another way, as necessary as the electric vehicle is to avert the harmful effects of climate change, decarbonization of the steel and cement industries is more important and has attracted a fraction of the attention and research dollars necessary to make it happen.**¹⁴ Investors who seek alpha and genuinely care about environmental issues have missed an opportunity by overlooking this reality. Investors must revisit their understanding of the relationship between economic performance and ESG variables to realize this potential. Most studies of ESG strategies have focused on the relationship between companies with strong ESG characteristics and market returns; given the prevalence of ETF de-risking strategies, which funnel money into firms that already have strong ESG characteristics, this is unsurprising.¹⁵

With this backdrop, it is also unsurprising that much of the investment community



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view environmental issues as either irrelevant to maximizing shareholder value or merely as a risk factor. **The reality is that environmental problems are an opportunity to drive alpha because when a company solves a material environmental issue for the business, management can improve returns and differentiate corporate strategy.** Corporations will have to implement substantial changes to address their respective environmental problems, and as they do so, they will create differentiated operating models.¹⁶ As Michael Porter recently noted:

If we recognize the enormous power of capitalism as a driver of positive social impact, by far the most powerful way to integrate social innovation and economic value is through a company's strategy. Creating social impact through an innovative and profitable business model reshapes the nature of competition and makes social impact a part of capitalism itself. This requires going way beyond a checklist of material factors.

Most changes will not confer any sustainable competitive advantage, but some will. Others will affect company valuation and performance by altering a firm's systemic risk profiles (lower costs of capital and higher valuations) and their idiosyncratic risk profiles (higher profitability and lower exposure to tail risk).¹⁷

When investors fail to recognize the connection between company strategy, corporate behavior, financial performance, and economic value, they fail to recognize an opportunity. For example, the cement industry is a critical industry for all developed and developing economies, which together use 4.2 billion tons of cement per year. Decarbonizing the cement industry is one of the most pressing challenges in shifting to a low carbon economy because the emissions (~7% of all global emissions) are process-related. Decarbonization thus requires the production of proprietary intellectual property that either change the manufacturing process or changes the chemistry of cement, either of which will likely confer a competitive advantage on the producer.¹⁸

Up for grabs is an industry currently worth \$312 billion. Who will claim it? Maybe it will be CEMEX, perhaps it will be LafargeHolcim, or maybe it will be Anhui Conch, China's largest producer. All are pursuing decarbonization strategies, and none of them can be found in an ESG ETF. Furthermore, they all have low ESG ratings because, although economically critical, their businesses pollute. **The economic criticality of a business does not change because the industry needs to find a way to decarbonize. Achieving a carbon-neutral economy does not mean we don't use cement and steel anymore; it means those businesses that produce steel and cement need to find a way to decarbonize.** They need to invest in research and development, in new assets, and in people. Decarbonizing cement may also come from a young startup/small-cap player, as it did in the auto industry. Although unlikely to create the same level of excitement that Tesla has, do any of us want to miss out on investing in the Tesla of any industry?

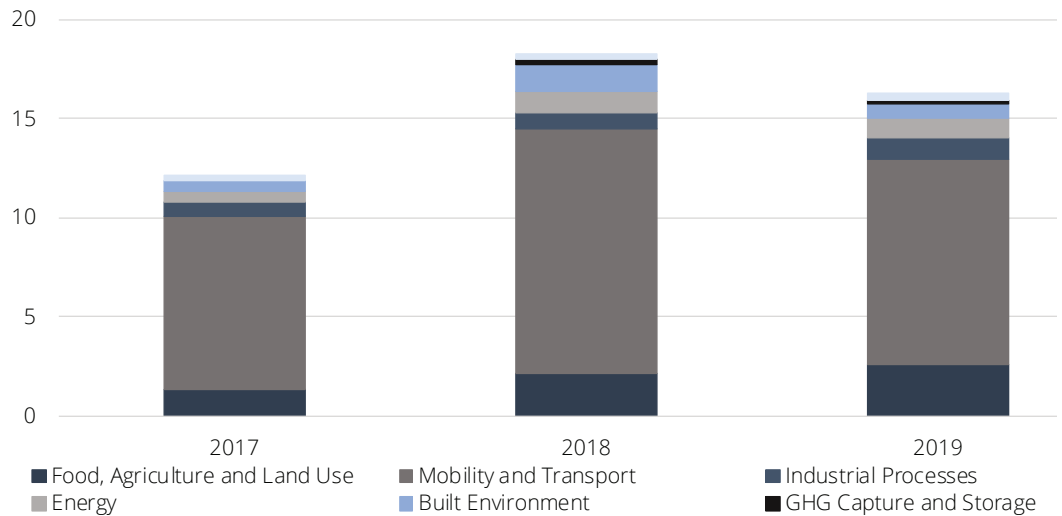
Transportation is beginning to emerge as the single exception to the divestment trend in carbon-intensive industries. Major auto manufactures do not appear to have benefited



much from a flow of new capital, but one business in that industry, Tesla, has. And although the causality is not this simple, it would not be outrageous to suggest that this single flow of capital has permanently changed the entire industry's strategy and direction, setting it on a path to eliminating 11% of annual greenhouse gas emissions.¹⁹

Although the chart presented to the right represents the flow of capital into climate-focused VC opportunities, we believe it is indicative of where investor focus is more broadly. Although Mobility and Transport are essential sectors to decarbonize, other sectors, especially in the industrial world, are equally important to decarbonize if we are concerned with climate outcomes, yet in many cases more difficult from a science and execution perspective to decarbonize. That sectors beyond Mobility and Transport attract little attention in markets, be they early-stage private markets or later stage public markets, is problematic.

VC Investment in Climate Tech Investment in Billions of USD



Source: Massif Capital, PWC, Dealroom

Decarbonization in the auto industry was not about finding ways to pull capital out, but rather, finding ways to put more capital to work. We feel comfortable asserting the same applies to other transitioning sectors, of which there are many. These other businesses may not be as sexy as manufacturing electric sports cars nor have Tesla's charismatic leadership. Still, they can make a significant environmental impact and generate meaningful returns.

In 2008, DONG Energy – a Danish energy company – was a profitable, stable fossil fuel producer. It was also widely acknowledged as one of the world's best developers of coal-fired power plants. Following a significant strategic shift in 2009, and a re-branding/re-listing of the firm as Orsted, it is now the world's leading offshore wind power producer.²⁰ The firm has reduced its emissions by 80% since 2006 and was named the most sustainable company on the planet in 2020. A decade ago, it was one of the most fossil fuel-intensive energy companies in Europe.

Since Orsted was listed in 2016, the company's value has more than doubled. Orsted is a transitioner. Nevertheless, this world-leading renewable power developer still only has an environmental ranking score of 7/10, according to Thomson Reuters, trailing far behind APD. Despite pioneering the offshore wind industry, it also only has an environmental innovation score of 5/10. That a poster child for decarbonization should rank so poorly, even now, after accomplishing all that any climate concerned investor could ask of a firm, speaks to the absurdity of trying to invest for impact via any product that relies on ESG rankings.



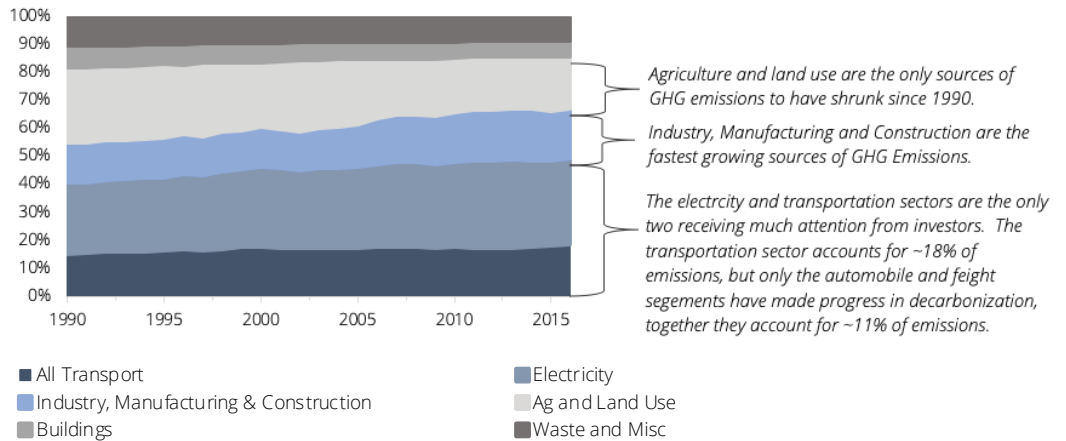
Investors who want to advance decarbonization must allocate capital not to ESG ETFs but to actively managed portfolios that focus on finding companies that are facilitating a transition through investment and strategy change.

ENABLERS

Unfortunately, renewables power sources are built from nonrenewable materials produced by businesses that tend to have larger carbon footprints and low ESG ratings.

The world's largest source of greenhouse gas emissions is electricity generation, which accounts for roughly 26% of all global emissions. Society has generally decided that a widescale build-out of renewable power sources (principally wind and solar) is the best way to address this issue. Unfortunately, renewables power sources are built from nonrenewable materials produced by businesses that tend to have larger carbon footprints and low ESG ratings. Mining firms, such as BHP, Glencore, and Freeport McMoran, produce many of the critical materials necessary to transition to a low carbon economy.

Sources of Global Green House Gas (GHG) Emissions Over Time



Source: Massif Capital, CAIT Climate Data Explorer via Climate Watch

Building a single 100-MW wind farm requires 30,000 tons of iron ore, 50,000 tons of concrete, and 900 tons of nonrecyclable plastic.²¹ A 100 MW solar development requires cement, steel, aluminum, and glass 150% greater than the wind farm.²² The 1,000-pound lithium-Ion battery one would find in most electric vehicles requires roughly 25 pounds of lithium, 30 pounds of cobalt, 60 pounds of nickel, 90 pounds of copper, 110 pounds of graphite, and 400 pounds of steel, aluminum, and various plastic components.²³ In total, mining firms will need, on average, to extract about 90,000 pounds of ore to produce that volume of useable material, much of which will be extracted using mining trucks that can haul 400 tons of material in a single load and get a sporty 0.3 miles per gallon of diesel.

Why is this important to know? Well, as a recent report commissioned by the Dutch Ministry of Infrastructure and Water Management pointed out: "An exponential growth in renewable production capacity is not possible with present-day technologies and annual metal production."²⁴ Which is to say we don't produce enough



metal fast enough to transition to a low carbon electrical grid. The answer the Dutch presented to this problem was to advance renewable energy technologies such that they become less material-intensive and less polluting in their manufacturing and increase investment in metals production. Put another way, invest in transitioners, and increase global annual production of critical materials, what we would term investing in enablers, the firms that produce the critical goods that “enable” a transition to a low carbon economy.

Mining is not the only enabler in need of investment, but it is one of the more pressing industries in need of investment. Not only is much of the investment in mining directed towards the wrong materials (40% of all exploration spending in the mining industry is directed towards gold mining), but the mine discoveries that are made are dropping in average size and quality. In short, more money needs to be spent today to maintain current levels of production than did 10 or 20 years ago, let alone increase the volume of production necessary to meet future demand.

Enablers, like mining firms, are often times transitioning firms also. Those mining trucks consuming 0.3 miles per gallon of diesel, they are going to be replaced in the future with electric trucks, such as the Kuhn Gruppe built [eDumper](#). The processing facilities that handle all of the ore extracted from the ground to build the 1,000-pound electric vehicle batteries, they are increasingly connected to renewable micro-grids or hydro-powered electrical grids. BHP, for example, will transition its Escondida copper mine in Chile, one of the world’s most important copper assets, to 100% renewable power by the mid-2020s and over the next five years, invest \$400 million into a climate investment program that will accelerate the use of low emissions technologies and natural climate solutions in their mining business. Investments in many enablers allow investors to double down on impact.

Because of the growth in future demand of enabling materials, in addition to the need to transition mining strategies to a low carbon footprint, investments in mining and metals enablers offer what we believe to be some of the highest returns and impact potential currently available in public equity markets.

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Conclusion

ESG investing is currently in vogue. The priority of place now being given to a more comprehensive understanding of companies that has come with that attention is good. Unfortunately, the efforts made by Wall Street to profit from the shift has not helped advance the primary goal of most ESG interested investors. ESG ETFs, by way of example, represent an investment in a strange combination of businesses that do no harm, make no difference, and may or may not be as green as they claim to be. That investor’s exposure to company-specific climate risks is reduced by investing in an ESG ETF is a reasonable claim but not a terribly meaningful one given the potential systemic risk climate change poses to the economy.

Investors interested in not only earning returns but also having an impact must change their way of thinking. De-risking and divestment are unlikely to produce the



desired results. Starving economically critical industries of capital will only exacerbate economic stress just as the economy needs to grow to accomplish the monumental task of rebuilding in a new carbon lite way. Carbon intensive businesses that are transitioning their business models, or that enable a broader transition to a low carbon economy are overlooked and underinvested in.

The transition to a low carbon economy calls for smarter investing in better businesses, not passively burying one's head in the sand.



Footnotes

¹[Tackling Climate Change – An Investor’s Guide, FT.](#)

²We are skeptical of the efficacy of this idea for multiple reasons, one of which we detail in the paper below. We are also concerned that implicit in the idea is the assumption that a better ESG scores is interpreted as meaning a firm has a more prudent and farsighted management team. To understand this, invert the assumption, if screening for high ESG scores reduces risks, you must be screening out companies that have poor risk management because they are riskier. How can a one size fits all strategy accomplish this? How can an analysis that does not assess ESG variables that affect a specific business and specific industry structure, accomplish this difficult goal?

³ESG ratings now commonly include “controversy scores.” These scores penalize companies when the rating firm identifies a news-based controversy that the ratings firm can link to specific global norm or convention that the company has transgressed.

⁴A core reason ESG ETF’s have emerged as one of the primary methods to help investors align their portfolio with their climate interests and values.

⁵Morgan Stanley, The Rise of ESG ETFs.

⁶[US Energy Related CO2 Emissions, EIA and Apple ESG Progress Report](#)

⁷We should point out that corporations, namely cash rich technology companies, have been leaders in renewable energy procurement for the last ~6 years in the United States. Their role in developing innovative energy contracts and being a large demand source for emerging technologies should not be understated.

⁸Ten largest holdings of all ESG ETF’s by AUM.

⁹This is not an overarching critique of passive investment vehicles (there are many good reasons for this type of product to exist). We do not find them appropriate however for capturing asset mispricings and furthering societal climate initiatives in an energy transition.

¹⁰[The MSCI US ESG Enhanced Focus ETF.](#)

¹¹Lomard Odier TerreNeuve Newsletter, November 2019.

¹²Massif Capital estimate based on CAIT Climate Data Explorer and publicly available climate transition strategies of difficult to decarbonise businesses.

¹³[Mission Possible – Sectoral Focus Cement, Mission Possible – Sectoral Focus Steel](#)

¹⁴It is not an exaggeration to suggest that decarbonization of the auto industry and the electricity industry, together representing a significant percentage of global emissions, but still less than half of all emissions, represent the lowest hanging fruit in the fight against climate change. Difficult to decarbonize sectors represent more than half of all carbon emissions, with airlines, responsible for only 2% to 3% of global emissions, being the only difficult to decarbonize sector to have really attracted any attention or meaningful research dollars.

¹⁵There have been so many studies looking at this question that there have in fact been several meta studies that have summarized the results of over 1,000 studies.

¹⁶[Why ESG Fails](#), Institutional Investor.

¹⁷In July of 2019 the Journal of Portfolio Management published a paper entitled “Foundations of ESG Investing: How ESG Affects Equity Valuation.” In this paper the authors demonstrate a link between ESG information and the valuation and performance of companies by examining three transmission channels within the context of a standard discounted cash flow model. The three transmission channels impact both the future cash flows of a firm, the numerator in a DCF model, and systematic risk exposure of a firm, the denominator of a DCF model. This study importantly also found that trend and momentum in the change of firms ESG profiles was a useful indicator of future changes in equity returns.

¹⁸[The Road to Green Concrete is Paved with Clay](#)

¹⁹The relationship between the transportation industry and the electricity industry, historically completely disparate industries, grows much tighter under an electrified transportation industry. For this statement to hold true, a majority of electricity production would need to be carbon neutral.

²⁰Orsted is named after the Danish physicist Hans Christian Orsted who discovered electromagnetism in 1820.

²¹To Get Wind Power You Need Oil, Vaclav Smil, IEEE Spectrum.

²²Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities, U.S. Department of Energy (DOE).

²³Mines, Minerals and “Green” Energy: A Reality Check.

²⁴Metal Demand For Renewable Electricity Generation in the Netherlands, Dutch Ministry of Infrastructure and Water Management.



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