IS NET-ZERO EMISSIONS BY 2050 FEASIBLE? WE DON'T THINK SO.

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MASSIFCAPITAL

With the goal of net-zero greenhouse gas emissions by 2050, governments, businesses, and individuals worldwide are taking steps to reduce their impact on the environment. But is this goal feasible, by which we mean, can it be accomplished given the social, economic, political, scientific and time constraints implicit in the goal? Furthermore, has the approach to achieving net-zero emissions been thoughtfully considered?

In our opinion, the answer to both questions is no.

We preface our explanation for our skepticism with a quote from development economist Albert Hirschman: "Any theory or model or paradigm propounded that there are only two possibilities — disaster or one particular road to salvation — should be prima facie suspect. After all, there is at least temporarily, such a place as purgatory."[1]

While Hirschman's notion applies to a number of global challenges, we believe it is especially relevant to climate change, where a singular approach and universal solutions [in this case, wind, solar, and EVs] are widely viewed as the "road to salvation." Unfortunately, once tested against the complexities of reality and considering that most problems are less malleable than models predict, such universal solutions appear unworkable and seem as likely to lead to disappointment and frustration as they are to lead to success.

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That's not to say we don't believe it's possible to achieve a net-zero economy. In our opinion, it is just not possible on the timeline given and with the tools currently available. Progress is possible — the technology and tools we have are great solutions for specific problems and they are producing progress as we speak. The goal (net-zero) is a good one, but the timeline is out of touch with reality. However, what many people fail to understand is that the transition to a net-zero economy is complicated by the fact that it requires changing critical and fundamental elements of life. It represents the single most significant industrial activity ever undertaken by humanity and requires wholesale reshaping and retooling of every aspect of society — from the cars we drive to the buildings in which we live and work to the food we eat.

In this paper, we examine the realities and roadblocks that challenge this timeline from multiple perspectives, including:

- **The basic necessities of life: Power, housing, and food**
- **The assets required to facilitate the infrastructure needed for the energy transition**
- **The hearts, minds, and behaviors of people**

Basic necessities of life: Power, housing, and food

Power: Fossil fuels currently supply ~83% of the world's commercial energy. This compares to 86% in 2000[2] — a minuscule decline of 3% in 20+ years.

As scientist and policy analyst Vaclav Smil noted in an interview with the *Los Angeles Times*: "What are the chances that after going from 86% to 83% during the first two decades of the 21st century the world will go from 83% to zero during the next two decades? Especially as a few weeks ago China announced additional 300 million tons of new coal production for 2022, and India additional 400 million tons by the end of 2023. We are still running into fossil fuels, not away from them."

Numerous hurdles and statistics that suggest it is unlikely we will close that gap between where we are today in our reliance on fossil fuels for commercial energy and where we want to be in 2050. Key among these is the lengthy process of applying for permits to construct electricity assets as well as the widespread "not-in-my-backyard" response to the buildout of these assets — in both the developed and developing world. Add to that the unsustainable economics of renewable energy OEMs, and the goal of net zero by 2050 seems even more unattainable. However, the most sobering statistic is the one offered by Smil. A 3% decline in fossil fuel reliance for commercial energy generation over 20 years is not going to get us to our goal.

Buildings & Housing: Decarbonizing the buildings sector would require increased capital spending at an average of $1.7 trillion per year between 2020 and 2050.[3]

Increased energy efficiency isn't achieved simply by switching to LED lightbulbs or installing solar panels. It requires significant investment in heat pumps, window changes, upgraded insulation, HVAC upgrades/replacement, and more. In the developed world, nearly every building constructed approximately 10 or more years ago would need to undergo some type of retrofit, and although the benefit would be material, addressing 17.5% of global greenhouse gas emissions, it's unlikely that it can be accomplished in 30 years.

Consider this: In New York City, there are one million buildings. Collectively, these buildings generate 70% of the city's greenhouse gas emissions. Let's assume, unrealistically, that each building required no more than eight hours of work to achieve a carbon footprint of zero, in essence a single easy workday. Applied across New York City's one million buildings, that eight hours of work per building adds up to one year of full-time work (52 weeks a year, for five days a week for eight hours a day) for 3,846 people, or ~50% of the current staff of the New York City Department of Environmental Protection.

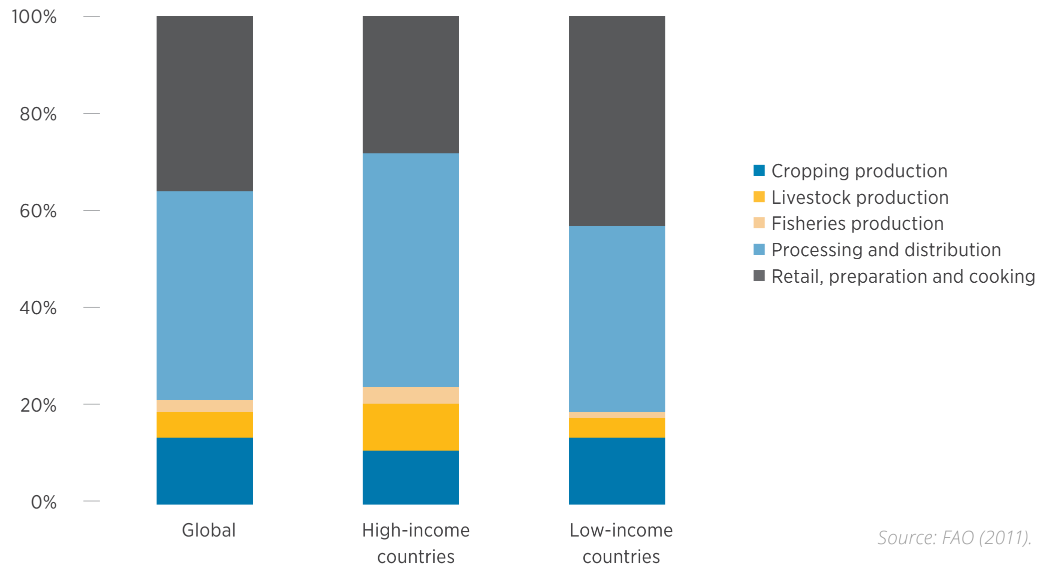
A similar thought process can be applied to housing. For instance, in the U.S., homes account for roughly 250 billion square feet of real estate. Let's assume 50% of these homes have a zero-carbon footprint — a false assumption, but let's go with it. If only five minutes of work per square foot was sufficient to retrofit the 50% of homes that are not yet zero-carbon, that would add up to 10.4 billion working hours or 260 million 40-hour work weeks. That's well above the roughly 6,132 40-hour works weeks between now and 2050, so upgrading just the residential real estate in the U.S. is sufficient to provide 42,468 people with full-time employment for the next 28 years. Is it doable? In theory, is it likely without a specific entity focused on nothing but this task? Not really.

A discussion of the transition to net-zero emissions would not be complete without considering energy use in the food sector. Fossil fuels are used in virtually every step of the agri-food chain — from farm to table.

Food: The food sector currently accounts for around 30% of the world's total energy consumption.[4]

A discussion of the transition to net-zero emissions would not be complete without considering energy use in the food sector. Fossil fuels are used in virtually every step of the agri-food chain — from farm to table. According to the Food and Agriculture Organization of the United Nations, approximately 25% of total energy is used in the production stage of food (crops, livestock, and fisheries), 45% in food processing and distribution, and 30% in retail, preparation, and cooking. In developing countries, a smaller share of energy is used in production while a greater share is used for cooking.[5]

Share of total energy consumption globally and in high-and low-income countries, by segment of agri-food chain



Source: FAO (2011).

If those numbers don't register, consider this: The total energy requirement for putting a kilogram of roasted chicken on the dinner table is at least 300 to 350 milliliters of crude oil or roughly a half bottle of wine. The mean energy required to put a kilogram of seafood on the table is 700 milliliters of diesel fuel.

Vaclav Smil points out in his book "How the World Works" that the total U.S. energy expenditure on food supply — after taking into account planting, processing, marketing, packaging, transportation, wholesale and retail services — is now approaching 20%. A large percentage of that comes from diesel use in farming, transportation, and fertilizer use, which are difficult to decarbonize. Before eliminating our reliance on hydrocarbons, we must determine how to produce food in their absence. We cannot decarbonize first then hope to figure it out later. At the moment we don't have a solution to this decarbonization problem without starving a large percentage of the world's population.

Assets required to facilitate the infrastructure needed for the energy transition

Infrastructure: For every pound of lithium-ion batteries produced, roughly 50 to 100 pounds of material must be mined, moved, and processed. Importantly, the mines necessary to produce this material currently don't exist, so the ore bodies also must be discovered.

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Essential to the decarbonization of the economy is electrification. And essential to electrification are Lithium-ion batteries, or at least that is what we have all been told. As a power source and energy storage solution for a wide range of applications, Lithium-ion batteries are in high demand — a trend that shows no sign of slowing. In fact, global battery demand is expected to increase from 185 GWh in 2020 to over 2,000 GWh by 2030.[6] It, therefore, stands to reason that demand for the raw materials needed to produce these batteries (lithium, cobalt, nickel, graphite, copper) will also rise. But these raw materials are not "on-demand." The mining industry has a long lead time, requiring years of production. For example, according to a report published by the World Bank, one-third of copper discoveries since 1950 have had lead times to eventual production of 30 or more years.[7] Given that timeframe, supply is unlikely to keep pace with rapidly rising demand.

Below is our analysis of the supply/demand outlook for raw materials needed in a grid powered by renewables. Note the years of production necessary to meet demand and the percent of global reserves required. While these numbers are meaningful, many challenging assumptions went into our calculations.

Metals & minerals production and reserves needed to accommodate storage for a renewables-powered grid and to replace the current fleet of gas-powered vehicles with electric vehicles (EVs) globally.

Metal	2018 Annual Production (Mil of Tonnes)	Mass of metal needed for storage necessary for a renwables powered grid and to replace the current autombile fleet with EVs (Mil of Tonnes)	Years of Production at 2018 Capacity required to replace automobile fleet with EVs and install necessary grid level storag of a renwables powered grid (Mil of Tonnes)	% of Global Reserves needed
Copper	21.0	472	22	57%
Nickel	2.3	422	183	474%
Cobalt	0.1	78	555	1126%
Lithium	0.1	60	706	429%
Graphite	0.9	612	658	204%

Source: Massif Capital estimates based on the tonnes of batteries needed electrify the grid as presented in Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely Replace Fossio Fuels, primary Massif Capital assumption was that the metal content of utility scale batteries was the same as EV batteries. This assumption is not without flaws but also is unlikely to produce result that are several multiples off the mark.

Source: Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely replace Fossil Fuels, Geological Survey of Finland

The table below uses the same math but focuses on replacing the world's fleet of gas-powered vehicles with EVs. These numbers are better, as there are less-complicated forward-looking assumptions (i.e., we know how many vehicles there are globally and how much metal the average EV has in it), yet they are still astonishing.

Replacing the world's fleet of gas-powered vehicles with EVs will require the following raw materials:

Metal	2018 Annual Production (Mil of Tonnes)	Mass of metal needed to manufacture 282.6 million tonnes of Li-Ion Batteries (mil of tonnes)	Years of Production at 2018 Capacity required to replace automobile fleet with EVs (mil of tonnes)	% of Global Reserves needed to replace automobile fleet with EVs
Copper	21.0	48	2	6%
Nickel	2.3	43	19	48%
Cobalt	0.1	8	56	114%
Lithium	0.1	6	72	44%
Graphite	0.9	62	67	21%

How were these numbers calculated: *Annual production and global reserve estimates come from USGS Mineral Statsitics data. Mass of metal needed for batteries is based on first an estimation of the volume of power required to do the useful work of the existing automobile fleet (how many miles are driven, what power is need to accomplish that work). That number is then converted into an estimate of the number of batteries necessary to store the given volume of power. Battery metal content is based on estimates from Argonne National Labratory for a non-descript NMC811 battery.*

Source: Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely replace Fossil Fuels, Geological Survey of Finland

These estimations provide perspective on the challenges of building out the infrastructure needed to reach net-zero emissions goals by 2050. They also hint at the massive investment in technologies and infrastructure necessary to reach these goals. Given these challenges, geoscience research agency Geological Survey of Finland concurs that additional thought needs to be given to supplemental solutions: "…replacing the existing fossil fuel-powered system (oil, gas, and coal), using renewable technologies, such as solar panels or wind turbines, will not be possible for the entire global human population. **There is simply just not enough time, nor resources to do this by the current target set by the world's most influential nations…this leads to the conclusion that the existing renewable energy sectors and the EV technology systems are merely steppingstones to something else, rather than the final solution.**[8]

Hearts, minds, and behaviors

Most citizens say they are willing to change how they live and work at least some to combat the effects of global warming, but whether their efforts will make an impact is unclear.[9]

As we wrote in the introduction of this paper, global decarbonization requires wholesale reshaping and retooling of every aspect of society. Before that can happen people's hearts, minds, and behaviors must change.

Although a study conducted by Pew Research Center in 2021 indicated that *most* citizens surveyed in 17 advanced economies were willing to alter *some* aspects of how they live and work, most and some aren't enough. Climate change is a global issue that affects every living thing. Therefore, all of humanity must work together to resolve this issue.

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While there is no global event in modern history that compares to the magnitude of climate change, we believe decarbonizing the global economy on a timeline would require a coordinated mobilization of society similar in scale to that which occurred during WWII. Both human and industrial resources shifted to support the war effort. Women took factory jobs that were previously dominated by men, factories were converted into manufacturing plants for military vehicles and weapons, and victory gardens were planted to safeguard against food shortages. The war necessitated that everyone stop, pivot, and make sacrifices. Transitioning to a net-zero economy by 2050 requires a similar mindset and approach. As the political will for such a change does not exist, nor the leadership to inspire such sacrifices, the collective action is a non-starter. In some regards, putting aside all the other significant challenges that must be overcome to achieve net-zero by 2050, the absence of political will is sufficient to make the 2050 goal outlandish.

Conclusion

We believe the goal of net-zero greenhouse gas emissions by 2050 is environmentally thoughtful, but not economically possible. Unless we can chart a technologically, politically, economically, and environmentally feasible path, pursuing this goal on such an aggressive timeline will result in the misallocation of capital. Capex will be spent quickly rather than thoughtfully. However, we also believe that, should we fail to achieve net-zero emissions by 2050, there is still hope. Yes, the problem will evolve, but so will our solutions, particularly if we take a more strategic and wholistic approach to investing in the development of solutions.

At Massif Capital, we thoughtfully allocate capital to businesses that are cognizant of how best to advance toward decarbonization in sustainable ways. We are focused on creating a portfolio of businesses from within the energy, basic materials, and industrials sector that balance the environmental and economic realities of achieving a carbon-neutral economy. We are not alone in our approach. Increasing investments and commitments from venture capitalists, governments, countries, cities, and businesses are helping to catalyze growth and development in this and other subsets of the real assets ecosystem. But throwing money at the problem will not make it go away. Almost every economic activity carries some sort of environmental cost. The question isn't about finding actives that are cost-free and super charging them with excessive investment, but rather identifying the opportunities that maximize the associated social and economic benefits while minimizing the environmental cost. We must be intentional and discerning when investing in decarbonization with the hope that the return on investment will continue well beyond 2050.

Endnotes

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Massif Capital runs a long/short equity strategy focused on global opportunities in liquid real assets and industrials. We prioritize downside risk management by investing in businesses we understand operating in the Basic Materials, Energy and Industrial industries.

Q&A WITH PORTFOLIO MANAGERS

In a Q&A, Massif Capital portfolio managers explain the benefits of real assets, the role real asset industries will play in the transition to a low-carbon economy, and the ways a long-short strategy can capitalize on the shakeout from this transition.

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