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The Energy Transition and the Role of Commodity Futures

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The world has committed to transitioning to a low-carbon energy system. Our current energy system, which has been dominated by fossil fuels, will transition to one that is increasingly electrified and powered by renewables, which will require massive amounts of minerals and metals.

This change in the commodities landscape will also change the nature of commodity futures investing. Massive amounts of investment capital and the right price signals are needed to create the supply of minerals and metals needed to build this new energy system, offering commodities investors new opportunities for earning financial returns, creating a beneficial social impact, and constructing well-diversified portfolios.

The projected gap between current supply and demand created by the energy transition is massive and will likely require the promise of higher expected returns – or a higher risk premium – to attract the capital that is needed.

Commodities futures investors provide that investment capital and liquidity, while supporting price discovery and risk management in the commodities futures markets. Participation in the futures markets helps create the price signals that guide investment into the commodities and technologies that we will need and away from the commodities we won't, and by investing in commodity futures, the investor provides risk capital by creating price certain demand for the new investment in commodity supply, which allows the commodity producers to hedge price risk and secure financing.

This is different from investing directly in the equity of the commodity producer. While investing in equity provides commodity producers capital with which to invest in new physical production capacity, if futures prices don't make the investment profitable, they likely won't.

For all investors, however, it is fundamental to understand that the energy transition, while uncertain, is also unavoidable. The risk posed by the uncertainties of the timing and nature of the transition cannot be avoided. Investors are primarily exposed to this risk through its impact on the macro-economic landscape and through the impact of energy prices on their non-commodity investments.

Introduction

The world has committed to transitioning to a low-carbon energy system. Net-zero pledges have been made by over 700 of the world's largest publicly traded corporations and by 136 countries that are responsible for over 90% of global GDP[1].

This energy transition to a low-carbon energy system is changing the commodities which power the global economy. In order to limit climate change, the world is determined to move from a fossil fuel-based energy system to one based on low-carbon alternatives energy sources, such as solar and wind. The investment in infrastructure required to build this new energy system is unprecedented in human history, and it will fundamentally change the commodities landscape.

As the International Energy Agency explains (IEA 2022, p. 5; emphasis added),

> *An energy system powered by clean energy technologies differs profoundly from one fueled by traditional hydrocarbon resources. Building solar photovoltaic (PV) plants, wind farms and electric vehicles (EVs) generally requires more minerals than their fossil fuel-based counterparts.* ***A typical electric car requires six times the mineral inputs of a conventional car, and an onshore wind plant requires nine times more mineral resources than a gas-fired power plant.*** *Since 2010, the average amount of minerals needed for a new unit of power generation capacity has increased by 50% as the share of renewables has risen.*

Current production and investment in this new commodities landscape is well-below what is needed to support the rapid production of solar panels, wind turbines, electric vehicles, and storage batteries, all required for meeting net-zero commitments on time.

Not only will this new commodity landscape replace the fossil-fuel based energy system with one based on metals and minerals, but it will make increasing use of renewable fuels, and a system of carbon pricing to guide the energy transition to low-carbon energy sources.

This is a revolutionary change in the global economy, and shift in priorities unlike any the world has undertaken before. Commodities investors will play a key role in providing the investment capital needed to make this transformation happen. In this note, we seek to explain the nature of the energy transition, its impact on the commodities landscape, and what it means for investors – in terms of their opportunities for earning financial returns, creating beneficial social impact, and achieving better portfolio diversification.

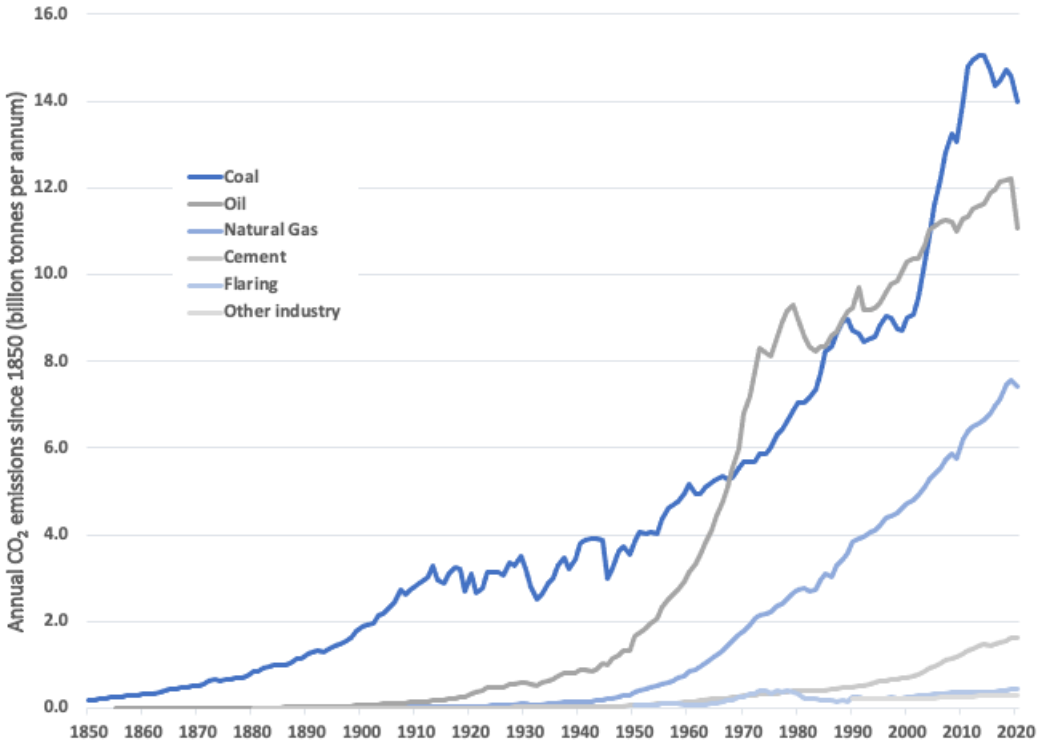
[1] Net Zero Tracker website (https://zerotracker.net)

The Energy Transition

Our modern world's energy system has been built on fossil fuels: coal, oil, and natural gas. The amount of carbon dioxide (CO2) released each year through our use of fossil fuels is staggering, close to 35 billion tonnes per year and rising. The burning of coal, predominantly in China and India, remains the largest source of carbon dioxide emissions. The consumption of oil and its refined products, including gasoline and diesel fuel, follows in second place. The use of natural gas comes in a more distant third place (see Figure 1).

Global carbon dioxide emissions remain dominated by the use of coal for power generation and oil for transportation

Figure 1: Global annual carbon emissions by source
Units: billion tonnes per annum



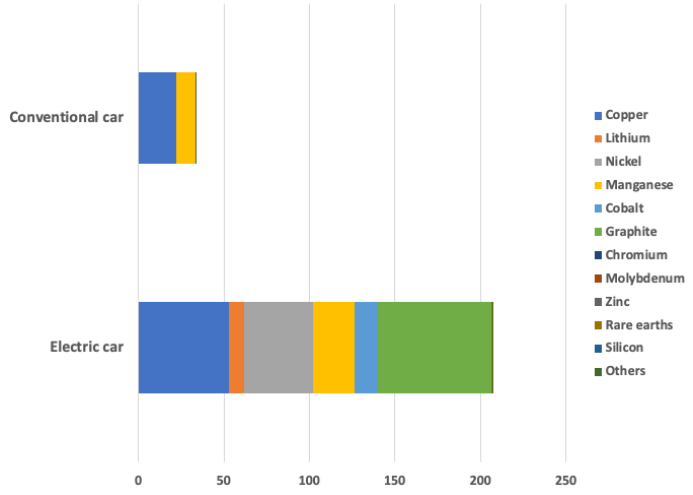
Source: Our World in Data. Carbon Project.

Consequently, in practical terms, the energy transition to a low-carbon energy system means both transitioning coal out of power generation and also expanding power generation to take oil out of transportation. Currently, this is planned to be achieved through the increased use of solar and wind in power generation and increased use of electric vehicles in transportation. This will dramatically increase the need for various minerals and metals for electricity generation, distribution, and storage, for natural gas to keep the electrical grid reliable as it becomes more depended on renewables, and for carbon pricing to motivate the switch to low-carbon energy sources.

For example, as shown in Figure 2a, a typical electric vehicle requires almost two-and-a-half times the amount of copper (53 kg) required by a conventional internal combustion engine vehicle while also requiring large amounts of lithium (9 kg), nickel (40 kg), cobalt (13 kg), manganese (25 kg), and graphite (66 kg). And as shown in Figure 2b, a typical offshore wind facility requires over seven times the amount of copper (8,000 kg) required by a natural gas facility per mega-watt (MW) of electrical power generation capacity while also requiring large amounts of nickel (240 kg), manganese (790 kg), chromium (525 kg), molybdenum (109 kg), zinc (5,500 kg), and assorted rare earth elements (239 kg).

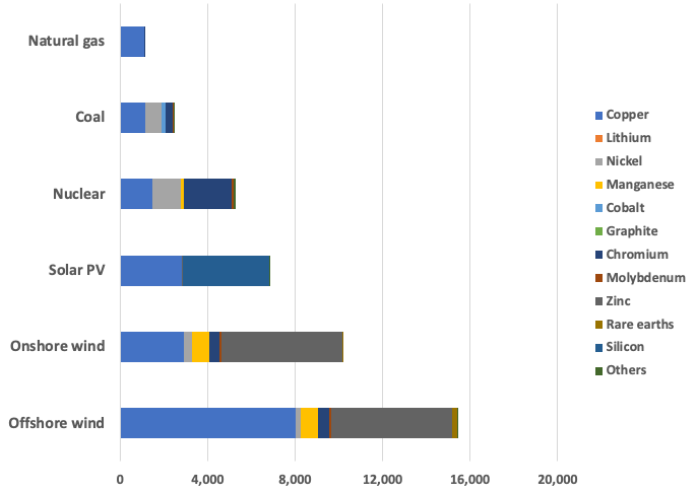
The rapid transition to a low-carbon energy system requires massive amounts of minerals and metals

Figure 2a: Mineral use in transportation*
Units: kg/vehicle



Source: IEA.

Figure 2b: Mineral use in power generation*
Units: kg/MW



Source: IEA.

**excludes steel and aluminum.*

The increase in demand for minerals and metals to support this transition will be massive. The exact mix of mineral and metals resources needed will vary depending on the technologies that come to dominate the new energy system, some of which may not exist today. However, since there is only one periodic table, future technologies will need to build upon the same chemical foundations.

As shown in Figure 3, the mix of minerals and metals required varies widely across different low-carbon technologies.

The mix of minerals and metals required varies widely across different low-carbon technologies

Figure 3: Minerals required for energy transition technologies
Units: color indicates relative requirement (high=●, moderate=●, low=●)

	Copper	Cobalt	Nickel	Lithium	REEs	Chromium	Zinc	PGMs	Aluminum
Solar PV	●	●	●	●	●	●	●	●	●
Wind	●	●	●	●	●	●	●	●	●
Hydro	●	●	●	●	●	●	●	●	●
CSP	●	●	●	●	●	●	●	●	●
Bioenergy	●	●	●	●	●	●	●	●	●
Geothermal	●	●	●	●	●	●	●	●	●
Nuclear	●	●	●	●	●	●	●	●	●
Electricity networks	●	●	●	●	●	●	●	●	●
EVs and battery storage	●	●	●	●	●	●	●	●	●
Hydrogen	●	●	●	●	●	●	●	●	●

Source: IEA.

Notes: REEs = rare earth elements, PGMs = platinum group metals,
Solar PV = photovoltaic solar power, CSP = concentrating solar power, EVs = electric vehicles

For power generation, photovoltaic (PV) solar panels require large amounts of aluminum (as well as silicon) while rare earth elements (REEs) are essential to the permanent magnets in wind turbines. In transportation, electric vehicle motors also depend on rare earth elements and on storage batteries, which in turn depend on cobalt, nickel, and lithium (as well as manganese). To enable this infrastructure, expanding the electricity networks and grids to power these electric vehicles also requires a massive amount of copper and aluminum, with copper being the key commodity needed for all electricity-related technologies.

In short, the energy transition requires a sea-change in the commodity landscape. Our energy system which has been dominated by fossil fuels will increasingly rely on massive amounts of minerals and metals. Not only will the energy transition need the electricity-related infrastructure to reduce the use of coal in power generation and oil in transportation, it will likely also require the use of biofuels in vehicles where electricity is not feasible or not economic. Natural gas, which is uniquely well-suited for generating power quickly when the sun doesn't shine or the wind doesn't blow, and yet has a far lower carbon footprint than coal, will continue to be needed to keep our power supply reliable while we are making it more environmentally responsible.

New non-physical commodities are also being created, notably in carbon emissions. Carbon markets are setting a price on carbon emissions and using market-forces to motivate the switch away from fossil fuels, as well as financing investment in this new commodity landscape.

Implications for Investors

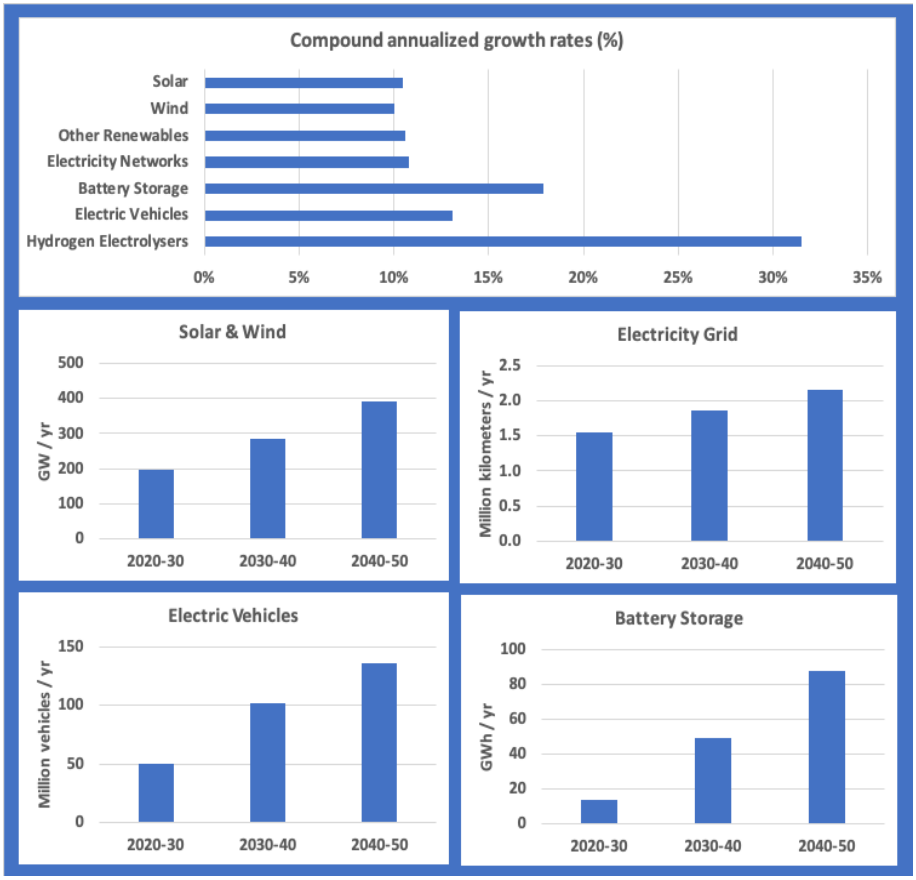
This change in the commodities landscape will also change the nature of commodity futures investing. Massive amounts of investment capital are needed to build the infrastructure of the new low-carbon energy system, and commodities investors will be needed to provide it and to send the price signals that incentivize producers to supply it. This requires a thoughtful reconsideration of prospective financial returns, the opportunity for beneficial social impact, and how to structure a diversified portfolio.

Prospective financial returns:

The changing commodity landscape defined by the energy transition creates the prospect for higher financial returns on those building blocks vital to support the transition. Demand for the minerals and metals required for electrification of our energy system and powering that energy system with renewables requires massive growth in supply. According to a study sponsored by Eurometaux (Gregoir 2022), the European non-ferrous metals industry association, demand for solar, wind, and other renewables is projected to grow at more than 10% per year over the next 3 decades, as is the expansion of the electrical grid, and production of storage batteries, electric vehicles, and hydrogen electrolysers (see Figure 4).

Current and announced government policies imply tremendous growth in production of low-carbon energy infrastructure

Figure 4: Annual capacity growth required to meet current and announced government policies on climate change (Gregoir 2022).
Units: annual capacity growth under IEA "STEPS" scenario



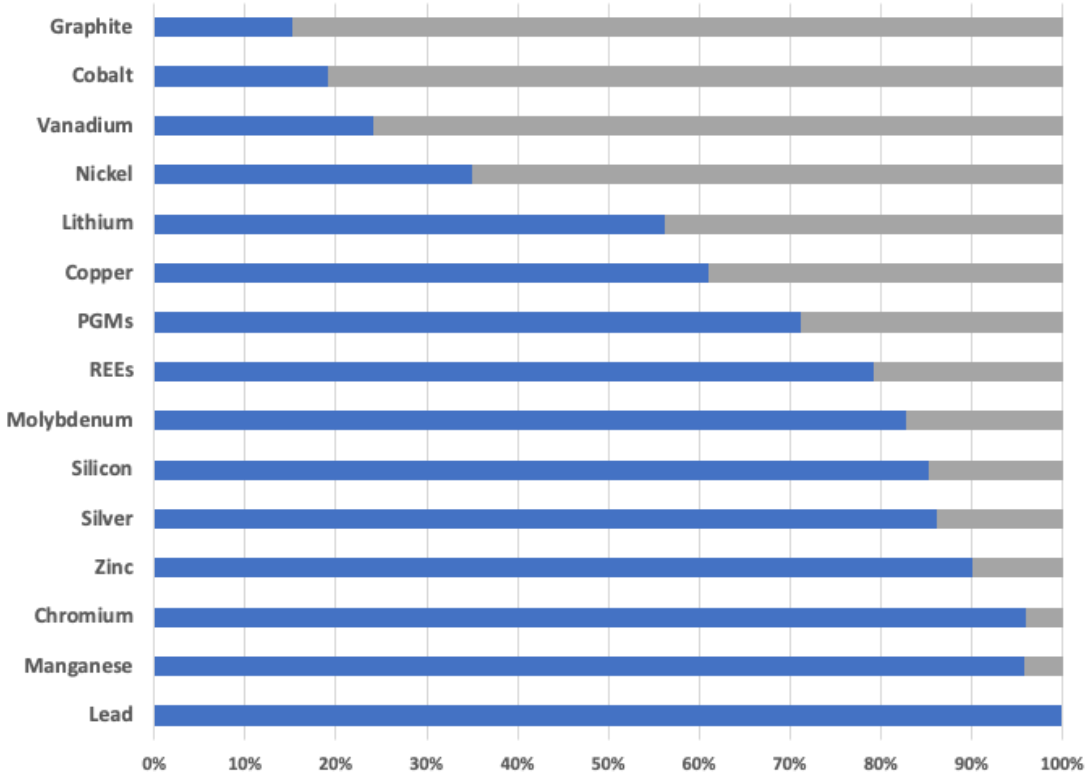
Source: KU Leuven and Eurometaux

Notes: The IEA "STEPS" scenario is a conservative estimate of what will be required as it includes only firm policies that are in place or have been announced by countries, including Nationally Determined Contributions, not what will be required to meet the goals of the Paris Agreement.

This massive imbalance between supply and demand will require significantly higher prices in order to balance, which should be supportive of higher overall returns on these commodities. According to an analysis by the IMF (Valckx 2021), across many of the commodities supporting the energy transition, the projected supply is now a fraction of the required demand. In particular, for copper, which is critical to the electrification of our energy system, current supply rates would meet only about 60% of projected demand over the next 3 decades. While the shortfall in storage battery metals such as nickel, lithium, and cobalt, is much worse (see Figure 5).

Current supply rates are a fraction of what the energy transition requires for a number of critical minerals and metals

Figure 5: Mineral supply relative to demand at current production rates 2021-2050
Units: Percent (%)



Source: International Monetary Fund (IMF).

Notes: PGMs = platinum group metals, REEs = rare earth elements,
Projected average annual demand from 2021-2050 relative to 2020 production rates.

The high level of investment required in infrastructure creates a strong strategic case for investing in these commodities. Further, the enormous gaps between projected supply and demand suggests that much higher prices will be required from time to time to motivate the investment in more supply and temporarily keep demand in check, creating the opportunity for strong tactical returns.

The investment required in these markets will likely require the promise of higher expected returns – or a higher risk premium – to attract the capital that is needed. Some of the new non-physical commodities, such as cap-and-trade markets in carbon emissions, are explicitly designed to increase in price either through a reduction in supply or an "inflation plus" floor or a mix of both. We would expect that these factors will be supportive of returns in these energy transition commodities over time.

Opportunities for beneficial social impact:

Today investors often want more than financial returns; they want to make a beneficial social impact with their investments (and ideally have both). At least since the time of Adam Smith, it has been well-understood that markets can harness the motivation for personal gain for the benefit of society at large, but it was Friedrich Hayek who argued that markets are essential in periods of rapid and uncertain change. This is precisely the situation we face today with the energy transition.

What he wrote in 1945 seems just as applicable to this modern phenomenon (Hayek 1945);

> *If we can agree that the economic problem of society is mainly one of rapid adaptation to changes in the particular circumstances of time and place, it would seem to follow that the ultimate decisions must be left to the people who are familiar with these circumstances, who know directly of the relevant changes and of the resources immediately available to meet them. We cannot expect that this problem will be solved by first communicating all this knowledge to a central board which, after integrating all knowledge, issues its orders. We must solve it by some form of decentralization. But this answers only part of our problem… There still remains the problem of communicating to him such further information as he needs to fit his decisions into the whole pattern of changes of the larger economic system.*

Ultimately, the impact of the energy transition will be felt at the level of the individual, in their day-to-day life. The means of communicating the information needed for that individual to fit their decisions into the whole pattern, is of course, the price system. In this way a decentralized market-based mechanism provides a much better means for society to adjust to changing circumstances than a centralized approach depended on government policy-makers. In the commodities futures markets, the futures markets coordinate actions across society by supporting the process of price discovery and risk management.

Price discovery is the process by which the market finds where supply and demand meet, and the benefits of incremental demand are balanced by the costs of incremental supply. Futures markets aid in discovering not only the spot price which balances current supply and demand, but in discovering the futures price at which the forward demand and supply meet.

Historically, the lack of a price on carbon emissions, like many pollutants, has led to a far greater emission of carbon than is socially beneficial. A price on carbon provides price signals and a mechanism to make low-carbon energy more competitive with fossil fuels. Current carbon markets have existed since 2005 and are regional, driven by government cap-and-trade schemes, like the EU Emissions Trading Scheme. More global voluntary markets are also developing and will require futures investors to provide the liquidity necessary to establish futures markets for the new commodities that will support the energy transition.

In other commodities, investors help create the price signals that guide investment into the commodities and technologies that we will need and away from the commodities we won't. For example, commodity investors who anticipate the need for more copper and less coal due to the energy transition, will bid up the futures price of copper and down the price of coal. The higher forward price of copper will encourage investment in new copper mines, while discouraging investment in coal mines.

Importantly, the futures market allows those new copper mines to lock in the price for the copper they will produce in the future. This ability to manage price risk through hedging, unlocks a flow of risk capital into this new infrastructure. By investing in commodity futures, the investor provides risk capital by creating a source of price certain demand – or offtake -- for the new investment in commodity supply, which allows the commodity suppliers to hedge price risk and secure financing.

This will likely require a new generation of benchmarks in commodity futures, built with the objectives of the energy transition front and center.

Participation in the commodities futures markets provides the liquidity and investment capital to support both price discovery and risk management. This is different from investing directly in the equity of the commodity producer. While access to less expensive capital will help them invest, if futures prices don't make the investment profitable, they likely won't.

Instead, the commodity futures investor makes a more direct impact on price and, through a clear price signal, motivates the investment in the infrastructure that will be needed to support the energy transition. While the equity investor gives a company money to do with as they think best, the commodities futures investor allows a company to earn money by producing the commodities that are required for the energy transition.

Finally, as some combination of the metals and minerals will be required whichever technology comes to dominate the net-zero landscape, the commodities futures investor is potentially less exposed than the equity investor to technologies or companies becoming stale and outdated.

Portfolio diversification:

The energy transition is a tremendous undertaking, and the length of time that it will take to accomplish could extend far out on one's investment horizon. The European energy crisis in 2022, which was well-underway even before the Russian invasion of Ukraine, demonstrates the difficulties in transitioning away from fossil fuels before building out the necessary capacity and infrastructure for a low-carbon energy system. In Europe, this has led to sky-high prices on fossil fuels, power, and moving back to coal-fired power generation to meet the demand for power. This is clearly not the outcome desired, but it's what happened.

The lesson for investors is that that the path to a new low-carbon energy system will not be a straight one. The energy transition will likely proceed in fits and starts, with the energy mix in use at any time subject to considerable variation, which presents significant risk. Commodities futures investors will want the protection that comes with diversification. From this perspective it is prudent to hold a basket of both the energy transition commodities and of the traditional commodities. And within one's basket of energy transition commodities, one will also want to hold a diversified basket as the precise mix that will prevail remains uncertain.

Many commodity futures investors hold commodity futures because of their ability to protect portfolio returns from inflation (Greely 2021). Crude oil futures, the benchmark for the price of energy in our current energy system, have typically been one of the best inflation hedges. But it likely won't be in the new energy system. What will be the "energy price" post-oil? Will it be the price of electricity? Or of the commodities that determine the price of electricity at the margin, such as natural gas? Or will it be the price of carbon? Which will be the inflation hedge. For commodity investors looking to hedge inflation risk in a new low-carbon energy system, a diversified basket of these commodities will likely be the best inflation hedge.

Conclusion

In a world where there is this much uncertainty, it is important for investors to realize that there are no easy answers, and this will be a dynamic process. When investing in commodities one will increasingly need a strategic partner with an experienced team to help guide you through it. As this generational transformation develops, we will all have to adapt, likely many times. When liquidity improves, new markets will be accessible to investors. It's important to note that Tesla was not in the S&P500 less than 2 years ago. Looking back from 2030, the commodities future investor will likely find a very different commodity landscape – be holding very different commodity allocations – than they do now.

However, it is fundamental to understand that the energy transition, while uncertain, is also unavoidable. The risk posed by the uncertainties of the timing and nature of the transition cannot be avoided by simply not investing in the relevant commodities. Investors are primarily exposed to this risk through its impact on the macro-economic landscape and through the impact of energy prices on their other investments. Just look at the impact in Europe. Instead, investors should see commodity futures investments in energy transition commodities as another important tool in their overall strategy for constructing a well-diversified portfolio.

Appendix

Biography:

David Greely has over 25 years of experience creating and communicating the insights and investment content necessary to solve his clients' most meaningful investment and risk management problems. He creates these insights through original research using economic reasoning backed by robust empirical analysis and communicates them with clients through written reports, discussions, and conference presentations, including thousands of client meetings over the years with key decision-makers and their staff at pension funds, sovereign wealth funds, hedge funds, investment banks, government agencies, and major corporations around the world.

David is an economist and investment strategist. He is the Senior Economic Advisor at Abaxx Technologies, where the team is preparing to launch a next generation commodity futures exchange and clearinghouse through Abaxx Exchange, which will support the Abaxx Smarter Markets vision by facilitating the energy transition to lower carbon emissions and increasing transparency around ESG-related metrics.

Until 2017, David was a Portfolio Strategist at Bridgewater Associates, where he was one of the senior members of the research team selected by the CIOs to advise and to conduct custom research projects for clients, applying Bridgewater's investment principles and processes to the investment challenges of these large, sophisticated institutional investors.

Prior to joining Bridgewater in 2012, David was a Managing Director in Global Investment Research at Goldman Sachs, where he was the Chief Commodities Strategist and Head of Energy Research. In his research, he created conceptual frameworks and analytical models capturing the relationships between commodity prices, supply and demand fundamentals, financial market positioning, and the economic environment. He authored numerous original research studies on commodities as an asset class and on the role of commodities in investment portfolios while also publishing regular market commentary, price forecasts, and trading recommendations for the energy and gold markets. David has also worked as a Research Economist at the Federal Deposit Insurance Corporation (FDIC) in Washington DC, and as a lecturer in Economics at the University of Chicago.

He completed his A.B. in Economics and Chemistry with Honors from the University of Virginia, where he was an Echols Scholar. David earned his Ph.D. in Economics from the University of Chicago as a Century Fellow, writing his dissertation under Nobel Laureates Robert Lucas, Jr. and Gary Becker.

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