JENNISON ASSOCIATES

PERSPECTIVES

July 2024

Fueling the Future

PGIM's recent Megatrends report reinforces Jennison's "all-of-the above" approach to capturing the decarbonization investment opportunity.

"Nations have risen and fallen, governments come to power and been ousted, and businesses created and destroyed, all in the quest for energy." [i] *Today we stand at a critical inflection point for the energy system.*

Jennison's Decarbonization Philosophy and Approach

- The Jennison Carbon Solutions team believes the decarbonization economy represents a significant opportunity for long-term investors to generate alpha across a broad spectrum of sectors.
- We expect the pursuit of carbon-reduction goals to drastically alter a wide range of industries, including electricity generation and transmission, infrastructure, transportation, forestry, and agriculture.
- In our view, this will lead to a rich and diverse opportunity set as decarbonization initiatives and policies play out over multiple decades.
- At the same time, we regard the journey to a low carbon economy as a process, not an event. Thus, we expect lower-carbon fossil fuels to play a part in the journey, with cleaner fossil fuels acting as transition fuels, bridging the gap until carbon-free energy can form the bulk of energy usage in the world. Renewables, while rapidly growing, are still a relatively small part of the current energy mix and, as the energy transition unfolds, an "all of the above" approach to energy production will be needed to meet demand affordably.

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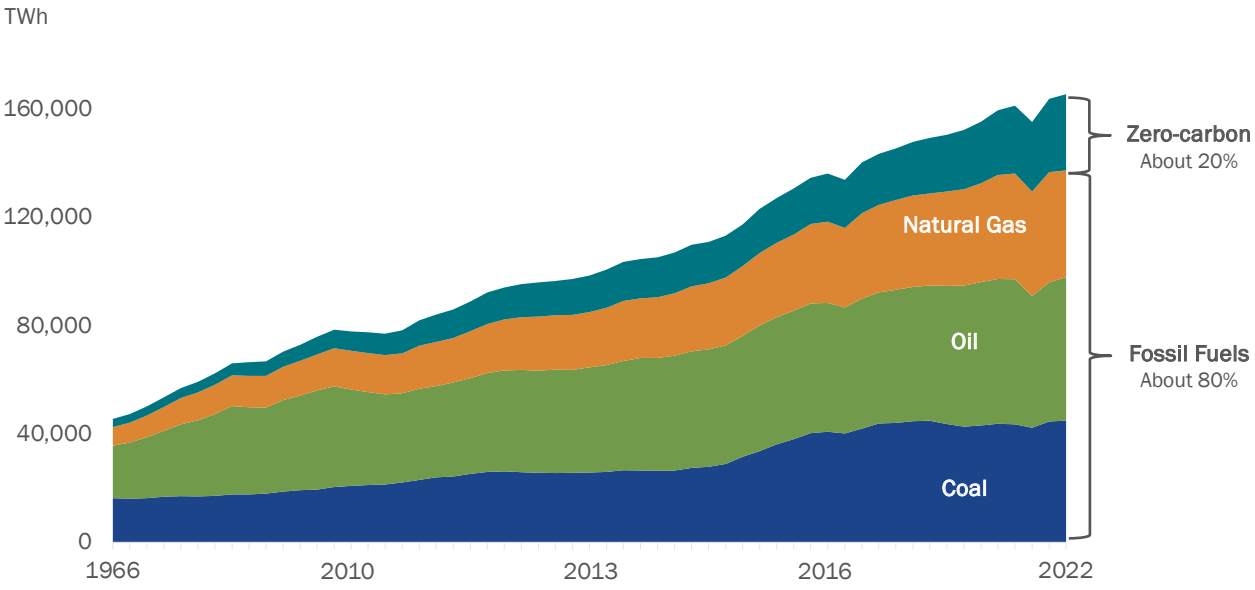
The conclusions from a recent Megatrends report by PGIM's Thematic Research team support many of Jennison's views on decarbonization and the related investment opportunities. The following is an excerpt from *Fueling the Future, Investing Across the Global Energy Landscape* that was published in May 2024, modified slightly to reflect the views of the Jennison Carbon Solutions team. The full Megatrends report can be accessed here.

Reliance on Fossil Fuels is Expected to Continue for Decades

For investors with ESG goals or decarbonization commitments, the inescapable arithmetic of global energy demand and supply means that fossil fuels will remain a major source of energy supply for decades to come – despite the ongoing and necessary transition to a low-carbon economy. Such a world will need considerable nuance – and a simplistic strategy that divides the investment world into "brown villains" and "green heroes" will *not* be the most effective approach to achieve either environmental or fiduciary objectives.

Our global economy has evolved over decades with fossil fuels as the primary source of energy. They currently provide 80% of all energy and are likely to remain a significant component of global energy supply for decades (Exhibit 1).

Exhibit 1: Fossil fuels power today's world



Note: Zero-carbon includes solar, wind, biofuels, hydropower and nuclear.

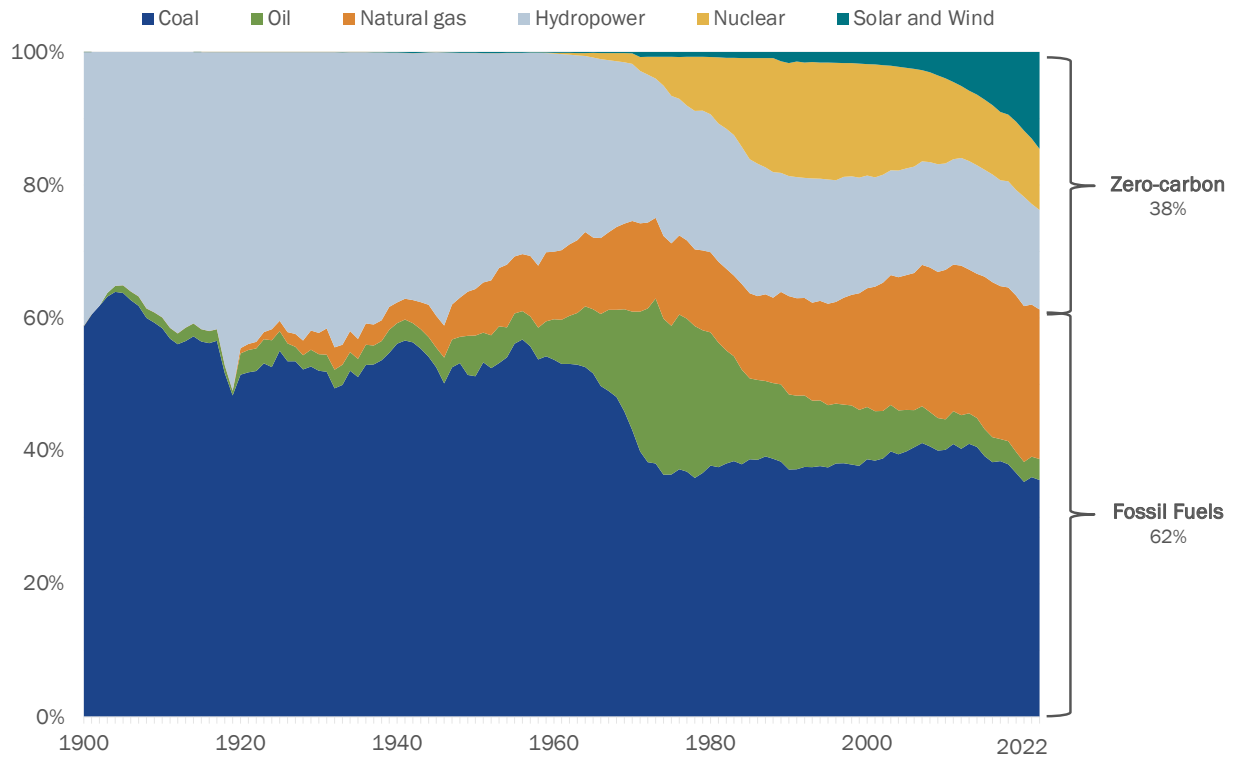
Source: US Energy Information Administration, Global Energy Outlook 2023. March 2024.

There are multiple reasons for the continued significance of fossil fuels, but three factors are often underappreciated in discussions on the pace of the energy transition. First, there are many specific industrial uses where renewables may not offer a complete substitute for fossil fuels. Second, the elaborate global infrastructure network for fossil fuels provides a huge incumbency advantage over renewables. Third, permitting issues and NIMBYism contribute to a lack of capital for critical renewable infrastructure.

Nobody is Perfect: Tradeoffs in Sources of Electricity

Today, electricity accounts for 20% of all energy consumption. Under some electrification scenarios, that share could potentially reach 50% by 2050.[ii] Given the massive investment poured into renewable power generation globally by governments and private industry, it is striking to note that more than 60% of all electricity is *still* generated from fossil fuels (Exhibit 2).

Exhibit 2: Global electricity generation still relies on fossil fuels



Source: PGIM Thematic Research, Ember and Pinto, et al; 2023. March 2024.

Of course, this aggregate figure masks the tremendous variation across countries – for example, India generates almost 75% of its electricity from fossil fuels while less than 5% of Norway's power comes from them.[iii] And one country is very prominent at both ends of the energy transition. China is not only one of the largest consumers of fossil fuels – using enough coal annually to power the entire United States – but also a leader in the transition to renewables – China added more solar and wind capacity in 2023 than the rest of the world combined.[iv]

An optimal energy system would not only have secure access to primary sources and key components, but it would also provide electricity cheaply when it is most needed and without harming the environment. What is often overlooked is that *no single source of electricity is optimal across these three fronts*. That is, fossil fuels and zero-carbon sources present different tradeoffs.

1) Dispatchability

Dispatchability is technical jargon for the ability to generate power when it is needed, i.e., how easily power production can be turned up or down to meet variations in demand. Previously, electricity was managed around baseload – the minimum level of power demand at any time during the day. In periods when demand increased above the baseload, complementary sources of power could be switched on as needed to meet the rising electricity demand and then shut off as demand declined overnight. Baseload power was typically provided by plants (such as nuclear or coal) with low marginal cost but little ability to adjust output, while complementary power plants (often natural gas turbines or sometimes hydropower) had a higher marginal cost of production but were dispatchable – that is, their production could easily be dialed up or down to respond to daily fluctuations in demand.

By contrast, most renewables – especially solar and wind – are intermittent. That is, their production is not easily adjusted – and they have considerable variation in production over the course of a typical day. The more renewable power on the grid, the greater the swings between minimum and maximum complementary power production within a day. This has created a new set of infrastructure needs and challenges as intraday supply-demand imbalances need to be actively managed by grid operators.

Current electricity grid and transmission infrastructure is heavily reliant on dispatchable power sources to meet these daily fluctuations in demand. Because of this, simply replacing baseload and complementary fossil fuel sources with more intermittent renewables can lead to significant challenges downstream.

Managing grids with extensive intermittent power sources is feasible – but renewable power generation needs to be paired with complementary infrastructure to enable it. Utility-scale power storage capacity, for example, could be used to meet daily fluctuations in demand. In the absence of sufficient storage capacity, easily dispatchable power sources (like some hydroelectric or natural gas) or long-distance transmission lines that can help balance power between multiple grids are needed.

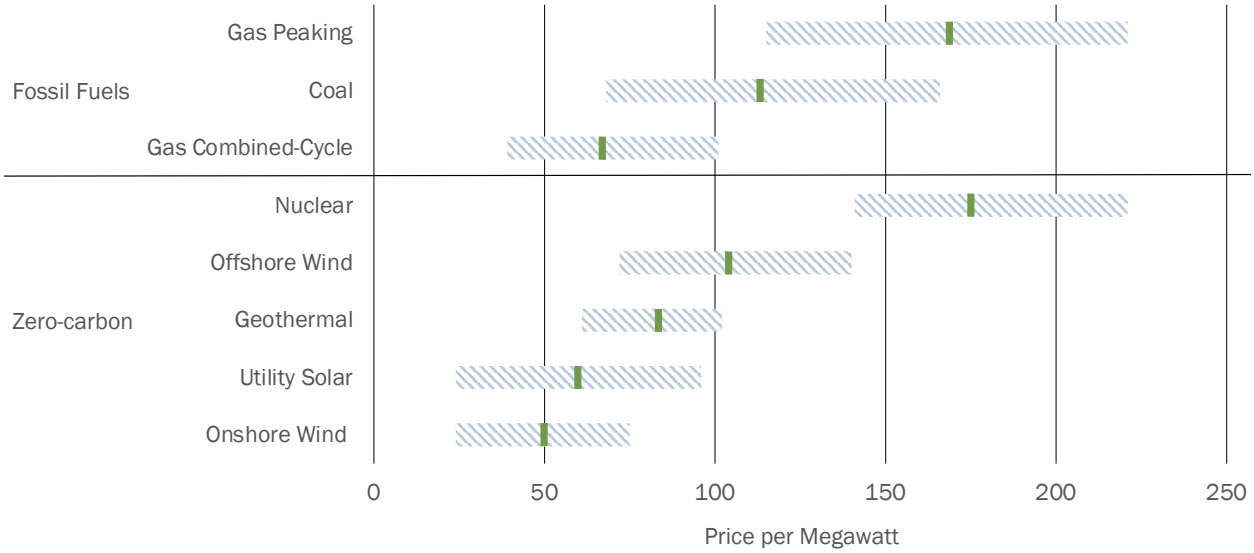
2) Affordability

More than 2 billion people globally – just under a third of the world's population – lack access to clean, affordable energy and still cook their food over open fires or on basic stoves burning wood, charcoal or other biomass.[v] And few developments can trigger universal political backlash quite like rising energy and electricity prices. A surge in energy prices in 2022 generated cost-of-living crises and political protests across the globe – from emerging markets like Pakistan and Ecuador to developed markets like the UK and France. Consequently, governments and politicians have very little incentive to compromise on energy affordability.

Over the past decade, government support of wind and solar has attracted private capital which in turn has enabled and accelerated technological advancements that now make solar and wind amongst the most cost-efficient sources of electricity. In fact, several research studies have shown it would be less expensive to build entirely new arrays of solar panels or clusters of wind turbines and connect them to the US grid than it is to keep operating existing coal plants in the US.[vi]

Renewable power projects like solar and wind generate electricity today at a relatively low levelized cost of energy (LCOE) – that is, the total cost of power generation over the lifetime of the asset – and have the added feature of zero marginal cost of production again over the asset's life, ignoring the inherent cost of intermittency of those power sources (Exhibit 3).

Exhibit 3: Renewables have become the cost-effective way of generating electricity



Note: LCOE has its limitations. For example, it does not account for the additional cost of power storage for intermittent sources to smooth out the fluctuations in their production. But even after adding the cost of firming intermittency – such as the cost of power storage or the need to supplement these renewable sources with dispatchable gas-powered plants – renewable sources remain cost-efficient in most cases – especially compared to nuclear and coal-powered plants. Source: PGIM Thematic Research, Lazard and International Energy Agency. March 2024.

3) Carbon emissions

2023 was the warmest year in recorded history – both on land and in the ocean – and the latest example of a persistent increase in global temperatures.[vii] [viii] Greenhouse gases (GHG) – like carbon dioxide and methane – in the atmosphere are a key factor contributing to warmer temperatures.[ix] This persistent global warming is causing ice caps to melt, driving rises in sea levels and generating more frequent extreme weather events – whether they're droughts and floods or more intense storms and wildfires.

Energy – both its production and consumption – accounts for roughly 75% of global GHG emissions.[x] Nearly all of this comes from combustion of fossil fuels. By contrast, renewable sources – once manufactured and in place – can generate electricity with no additional GHG emissions.

A low-carbon energy system – one that features more renewable sources rather than fossil fuels – is critical to reducing global GHG emissions. Regardless of how long it takes to achieve decarbonization goals, reducing carbon emissions will remain an enduring feature of the energy landscape for decades.

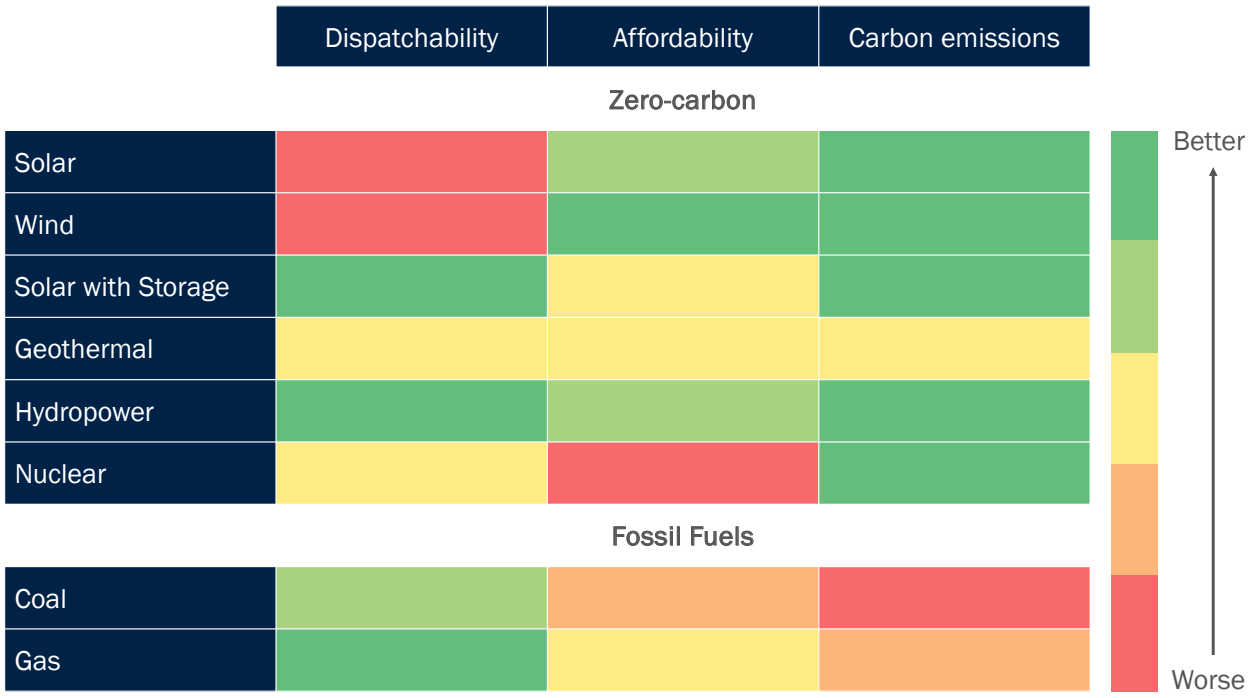
Over 140 countries – including the largest GHG emitters – have made carbon reduction pledges.[xi] With so many countries, firms and investors across the globe focused on reducing carbon emissions, it has become a critical and material factor for all energy investors.

As the energy transition continues, fossil fuels will be increasingly displaced by renewables as a source of energy. However, it is important to acknowledge that no single approach to the energy transition will work for all countries at every stage of their development.

The energy system of the future will need a variety of different sources to achieve the best outcomes (Exhibit 4). Given that the dispatchability of fossil fuels complement the intermittence of renewable sources quite well,

the energy system of the foreseeable future will likely continue to incorporate both. Furthermore, diversifying energy sources amongst select renewable and fossil fuel sources can provide a much-needed element of resilience and security. More importantly, lower-carbon fossil fuels – like natural gas – can play a significant role and allow for energy security and affordability while the long-term transition is underway.

Exhibit 4: All sources of electricity offer different tradeoffs



Note: Affordability is measured by the levelized cost of energy and carbon-emissions captures emissions per BTU.

Source: PGIM Thematic Research, Lazard, International Energy Agency and US Energy Information Administration. March 2024.

The tradeoffs around electrification are very real, and the choices governments and societies make will be critical in determining the pace of the energy transition. Long-term investors seeking to navigate the evolving energy landscape will be faced with a range of investment opportunities and challenges.

Investing in the Decarbonization Economy

Is there a role for Big Oil in a new energy system?

Fossil fuels will almost certainly continue to be a component of the energy system of the future – albeit a smaller one and probably more in the form of natural gas than coal and petroleum. This new energy system promises to divide today's Big Oil majors into winners and losers. Some global oil majors will rely on the extended sunset of fossil fuels and focus their investments solely on continuing to provide fuels of the past – namely, petroleum and other fossil fuels. These firms run the risk of being rendered obsolete by efficiency gains and better infrastructure in renewables. They may ultimately be defined by the magnitude of their stranded carbon assets that are no longer economically viable.

However, there will also be a set of oil majors that will emerge as winners in the new energy landscape. They are more forward-looking, will lean into the energy transition and find ways to remain energy providers regardless of what the primary energy sources might be. Specifically, there are two ways for today's energy majors to remain winners in the energy system of the future:

- Transform their energy production to meet the needs of a new energy system
  Oil majors that are dynamic enough to shift their energy production to fuel sources of the future will likely remain prominent. Some are incorporating electricity into their current business models. For example, global oil majors BP and Shell are converting their vast network of gas stations into EV charging facilities in the UK and Europe.[xii] Others are leveraging their deep insight across the global energy landscape in trading molecules and electrons – that is, oil and gas as well as electricity.[xiii]
- Leverage their technical expertise to operationalize green innovations
  Much innovation in green technology comes from the research labs of oil and gas majors – and there is some evidence to suggest they do it better than energy tech startups. On paper, oil and gas majors not only have robust cash flows to commit significant amounts of capital to fund research, but they also have expertise in extraction, refining and other petrochemical processes to operationalize their findings. Furthermore, these firms have a track record of executing large and complex projects. For example, oil majors with elaborate refining operations can leverage those skills to advance and operationalize biofuels and sustainable aviation.

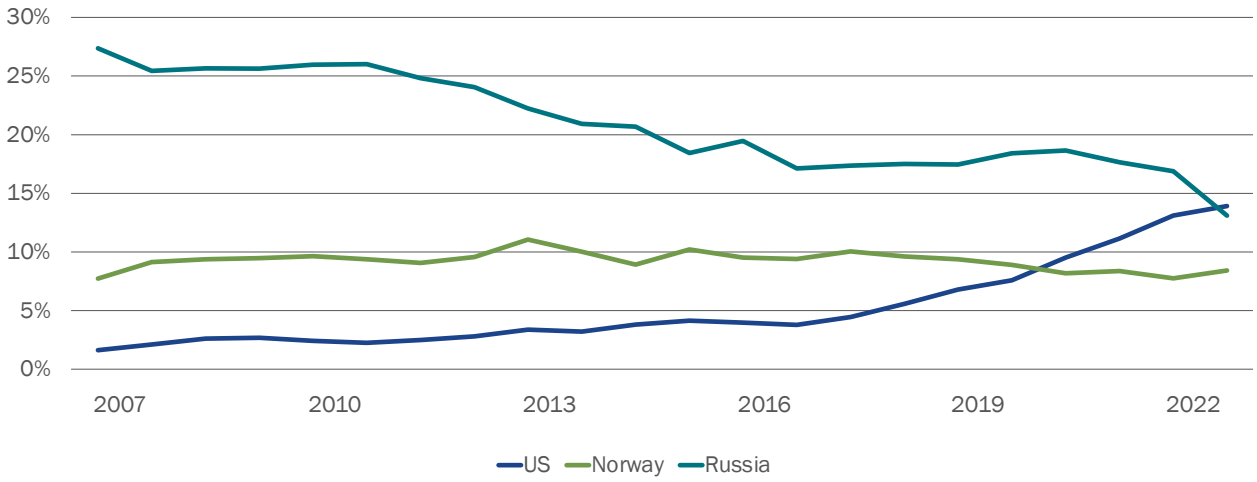
  Recent research analyzed the landscape of green innovation through the quality and quantity of green tech patents. This research identified oil and gas majors as key innovators around green technology and specifically found both the quantity and quality of green tech patents to be higher for traditional energy firms.[xiv] The research also indicates the patents from energy firms resulted overwhelmingly from in-house research (rather than acquisitions of startups) and more frequently led to real products that reduced carbon emissions and generated revenue. Shell, BP, and ExxonMobil were some of the leaders in green tech patents in areas like biofuels, carbon capture and hydrogen production.[xv]

Natural gas is displacing higher-carbon emitting fossil fuels

Natural gas is a key element to a low-carbon future by displacing higher-carbon emitting coal – especially in electricity production. In this capacity it can be valuable as a "transitionary" fuel source while renewable power generation, carbon capture technology, storage and transmission infrastructure get built. Indeed, global demand for liquified natural gas is expected to grow over 50% by 2040 as the coal-to-gas transition expands in China and South Asia.[xvi]

The surge in natural gas production between 2006 and 2023 globally was driven primarily by the US shale revolution. Hydraulic fracking and horizontal drilling techniques enabled the tapping of vast new US natural gas reserves, and this development launched a boom around liquified natural gas.[xvii] US production of LNG has nearly doubled - and will do so again over the next few years - and the US is now the world's largest exporter (Exhibit 5). Furthermore, Russia's invasion of Ukraine accelerated the LNG infrastructure boom in Europe and other regions. The ability to transport LNG more efficiently has ushered in a more globalized market and improves resiliency as suppliers can respond more quickly to global shocks.[xviii]

Exhibit 5: The shale revolution has transformed the US into a global natural gas powerhouse

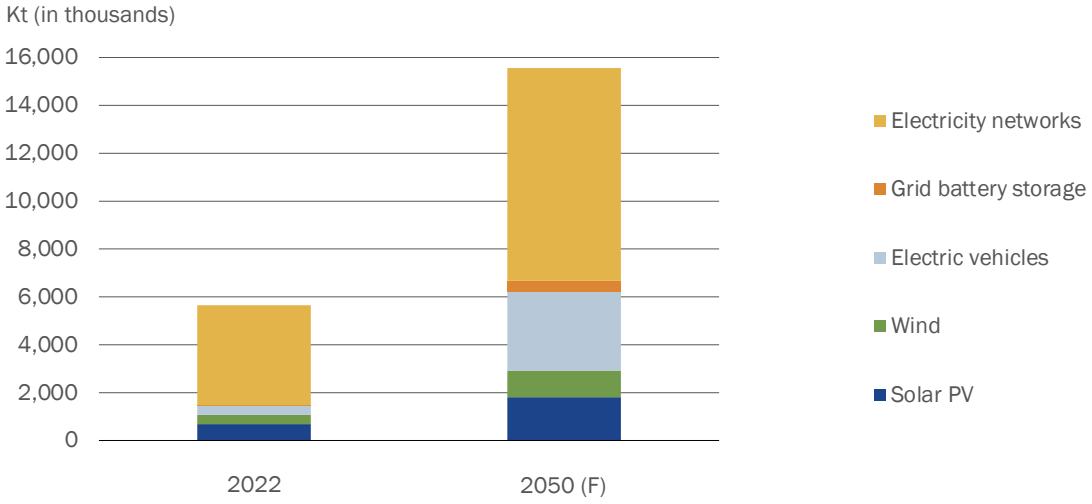


Source: Organization of the Petroleum Exporting Countries. March 2024.

Key components of the renewable supply chain

Metals and minerals are also critical components of the future energy system. While critical minerals like lithium and cobalt get much attention given their scarcity or concentration of processing, their demand is highly linked to current power storage technology and EV sales. By contrast, because of its extraordinary conductivity, resiliency and malleability, copper is essential to *all* aspects of electrification – from power generation to transmission to end-use applications like EVs (Exhibit 6). Because of its unique properties, it is difficult to engineer copper completely out of electric systems – unlike, say, cobalt. In fact, the need for copper across all aspects of electrification may sometimes be overlooked by markets. As electrification advances, the global demand for copper is set to double by 2050.[xix]

Exhibit 6: Copper is essential to electrification



Note: Shows IEA's assumption under the announced-pledges scenario. (F) indicates forecast.

Source: International Energy Agency. March 2024.

As for the supply of copper, it is usually found in remote locations, and mining is capital and time intensive.[xx] Additionally, approvals and permitting for new mines are becoming more challenging due to environmental concerns. As a result, building new capacity can take years and cost billions – new primary copper mines started between 2019 and 2022, for example, had an average lead time of more than 20 years between discovery and commercial production.[xxi] In fact, with declines of up to 25% in the average quality of copper ore being mined, some copper producers will have to spend more just to maintain their current levels of production.[xxii, xxiii]

Expanding and modernizing the grid

The near-universal need for larger and smarter grids presents providers of key grid components and construction services with a powerful macro tailwind. The International Energy Agency estimates that to power itself primarily with renewable energy, the world needs to add or replace nearly 50 million miles of transmission lines by 2040.[xxiv] Companies like Eaton in the US and Schneider Electric in France provide key components including inverters, transistors, switchgear and other substation components for transmission lines. Their central role in the energy transition over coming years may not be fully appreciated by the market today.

Jennison's Framework for Understanding the Decarbonization Investment Opportunity

Given the massive scope of decarbonization efforts, Jennison has developed a framework to help investors understand and quantify the opportunity set (Exhibit 7).

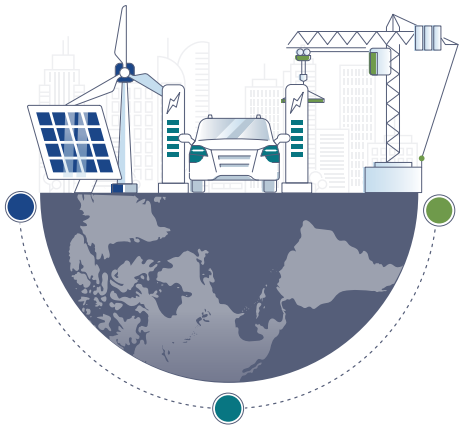
Exhibit 7: Understanding Decarbonization Opportunities at the Company Level

The pursuit of carbon reduction goals is altering industries and creating a diverse opportunity set that is underappreciated by many investors. We believe the companies best positioned for the new decarbonization economy fall into three categories:

SUPPLY

Companies that harness and/or produce lower- or zero-emissions fuels with the ultimate goal of replacing fossil-fuel power generation with clean sources.

- Renewables
- Electricity Generation
- Natural Gas
- Wind Turbine Manufacturers



DEMAND

Companies that improve the energy efficiency of existing infrastructure and replace fossil fuels in industrial processes.

- Industrial Applications
- Energy Efficiency & Storage
- Fuel Replacement
- Smart Buildings

ENABLE

Companies that provide technological innovations, equipment, infrastructure, materials, goods, and services that enhance power processing capabilities and create intelligent infrastructure.

• Technologies • Battery Reuse and Recycling • Power Grid Architecture

Source: Jennison. For illustrative purposes only.

As the global economy embarks on the complex journey towards decarbonization, the landscape of investment opportunities is evolving in tandem. Traditionally, the focus of investment in decarbonization has been on companies in the renewable energy sector. However, the decarbonization economy is far more intricate and expansive, presenting a diverse array of investment opportunities across a multitude of sectors.

The common perception of the journey to a low carbon economy is too narrow, and that is reflected in most decarbonisation, low carbon, and energy transition investment strategies. Understanding that getting from where we are today to the low carbon economy (without causing a significant drop in living standards or exacerbating energy poverty for millions—if not billions—of people) requires broad and deep changes in how we do things, with different trade-offs required along the journey. By including companies beyond the renewable energy sector, Jennison believes that investors can better align their portfolios with the multifaceted nature of the global decarbonization effort, while also potentially enhancing portfolio resilience and returns.

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Important Information

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