Energy and Natural Resources Report 2023

BAIN & COMPANY

Acknowledgments

The leadership team of Bain & Company's Global Energy & Natural Resources (ENR) practice prepared this report, with special direction from Grant Dougans, partner, and Clementien Valk-Fabels, practice senior manager.

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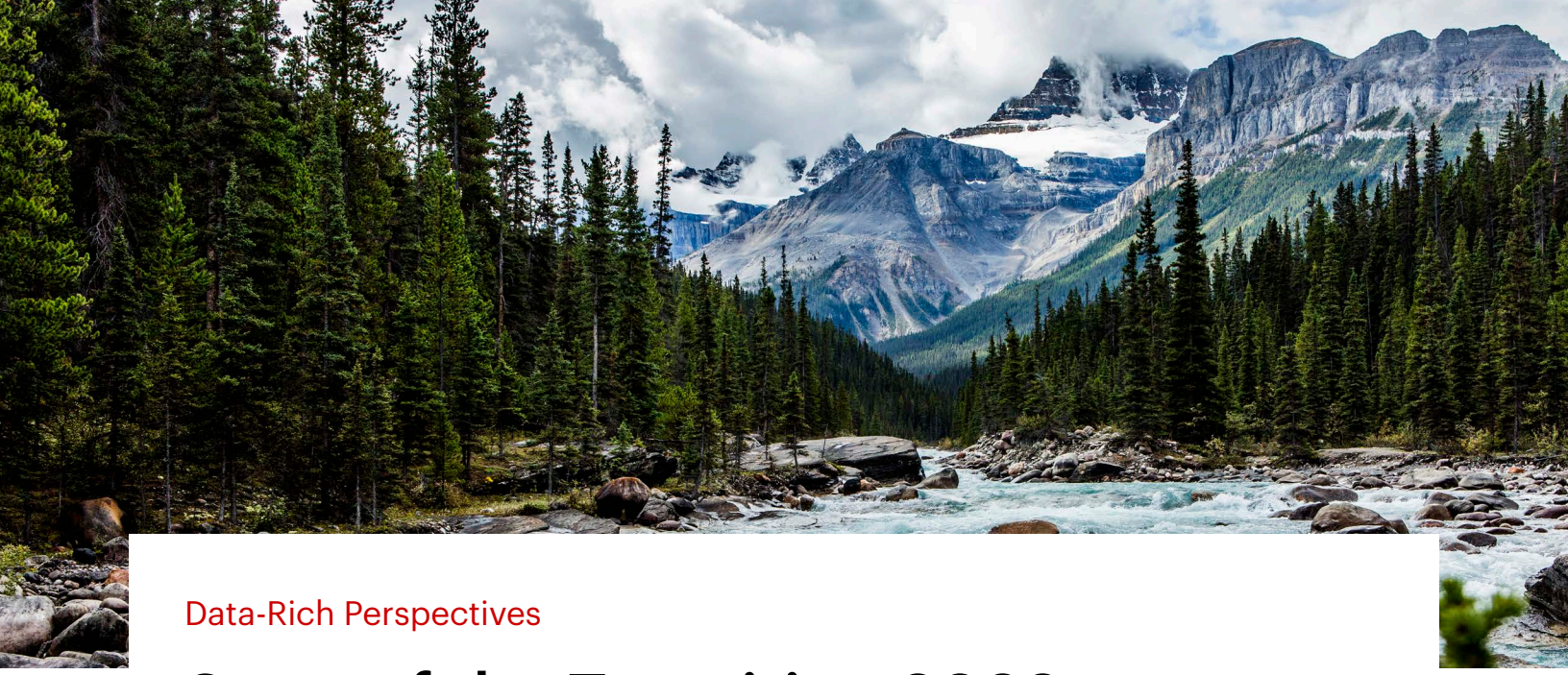


Data-Rich Perspectives

State of the Transition 2023: Global Energy and Natural Resource Executive Perspectives

Bain's third annual survey on the energy transition finds executives increasing investments in low-carbon businesses, but skeptical of consumers' willingness to pay more.

By Grant Dougans, Neelam Phadke, Alasdair Robbie, and Joe Scalise

At a Glance

- Executives believe their companies are outperforming the rest of the world in reducing emissions, but expect the rate of decarbonization to slow down over the next few years.
- Companies expect to deploy about a quarter of their capital on new growth businesses in 2023, many of these focusing on low-carbon technologies.
- Respondents say they aren't concerned about accessing capital for low-carbon businesses, but need to ensure adequate returns on those investments.
- Talent shortages are impeding growth, especially for technical experts, as well as frontline workers in North America.

Executives in the fields of oil and gas, utilities, chemicals, mining, and agribusiness are on the front lines of the energy and natural resource (ENR) transition. While concerns about climate change and extreme weather grow, and customers and shareholders call out for rapid decarbonization, these executives are tasked with changing the way the world produces and uses energy, food, and many critical materials—all while keeping their businesses viable.

At Bain, we work closely every day with executives in these industries across the globe. Our annual survey seeks to assess their opinions and attitudes about the progress of the energy and natural resource transition, how their companies are managing through these changes, and what barriers they see ahead. This year, we found executives expecting a slowdown in the rate of decarbonization in the short term (by 2030), though their long-term expectations remain largely positive.

Our 2022 report found executives grappling with increasing complexity and a disorderly transition as they balanced carbon-reduction efforts with the economic realities of their businesses. In the year since, we've seen this complexity exacerbated by geopolitics, which produced imbalances in the energy ecosystem and may have contributed to executives' belief that a short-term slowdown is at hand. Executives remain confident about their own abilities to manage through this complexity to a lower-carbon future, but are less confident about the world at large.

These findings come out of our discussions with clients and our survey in early 2023 of more than 600 executives across the energy and natural resource sector. As last year, we wanted to get a better idea of their views on the energy and natural resource transition, new technologies and investment opportunities, and where they see the greatest challenges for decarbonization.

Among the most interesting findings:

- Most executives still believe their own companies are doing better on the path to net zero than the world as a whole, and about one-third believe they're doing better than their peers.
- Companies expect to deploy 24% of their capital on new growth businesses in 2023. North America is catching up with Europe.
- Access to capital for new low-carbon investments isn't a major constraint, but ensuring a return on investment certainly is. Most customers aren't willing to pay much more to support these new businesses at scale, so companies will need government policy support to incentivize the investment.
- Renewables, artificial intelligence (AI) and other digital technology, and energy storage are the most critical technologies for the sector through 2030. Executives in the Middle East are bullish on hydrogen and carbon capture, but executives in most other regions expect these technologies to become more important only after 2030.
- Talent shortages are a significant barrier, especially for frontline workers in North America and the Middle East and for engineers and digital experts in all sectors.

Global perspectives

Executives anticipate a slowdown in the rate of decarbonization over the next few years *(see Figure 1)*. But a slowdown is expected to be modest, and their long-term expectations haven't changed. Although efforts to decarbonize are still progressing, turmoil in energy markets resulted in more coal being burned to make up for shortfalls in Russian-supplied natural gas. Several told us that the events of 2022 could shift the focus of investments back toward addressing scarcity and making energy affordable in the short term. However, geopolitical events also accelerated the deployment of capital to renewables as countries and companies look to become more self-sufficient.

"The success of the pivot to clean energy technologies will be determined by the extent to which people see the benefits while minimizing disruptions—with focus on affordability and fairness."

—New energy executive, India

Averaged across our survey participants, 2057 remains the consensus date when the world could reach net-zero carbon emissions *(see Figure 2)*. As a group, they expect emissions reductions to

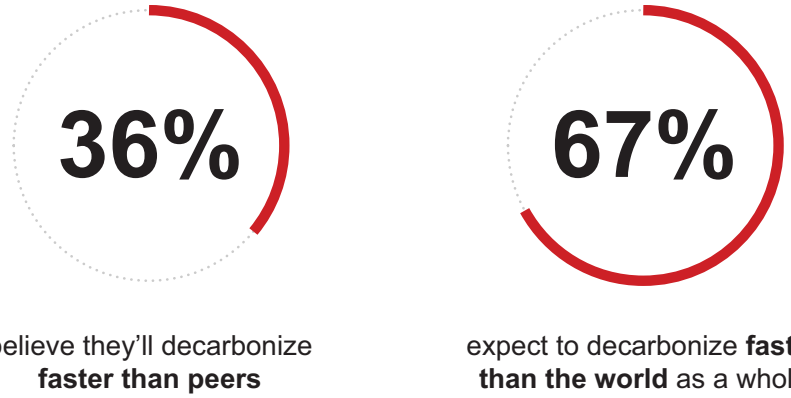
Figure 1: Energy and natural resource executives anticipate a slowdown in the rate of reduction of carbon emissions over the next few years

Expected change in global CO_2e emissions by 2030

Notes: Bain's 2023 ENR Transition Survey includes answers from 608 executives from more than 200 companies across 46 countries; 58% of the respondents were vice president or higher (including C-level executives and board members), and the combined market capital of the companies covered is about $4.5 trillion
Sources: Bain ENR Transition Survey 2022 (n=1,037); Bain ENR Transition Survey 2023 (n=608)

broadly track current pledges through 2030, then accelerate to achieve net zero by 2057. For this to happen, a lot would have to change after 2030. For example, the International Energy Agency estimates that for the world to reach net zero by 2050, annual investments in clean energy would need to increase to $4.6 trillion by 2030 from the 2022 level of about $1.6 trillion. All the while, the companies implementing these investments must also ensure that these projects are economically viable and can be executed given physical constraints (for example, availability of materials, labor, supply chain).

About one-third of executives believe their own companies are further along the path to net zero than their peers, and two-thirds believe they're moving faster than the world as a whole.



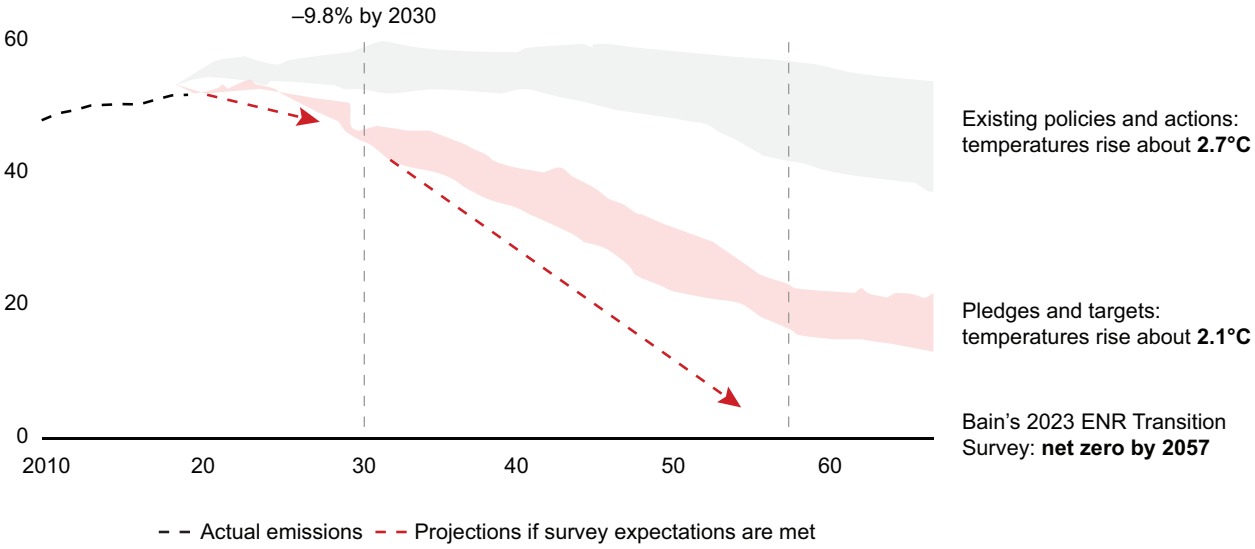
Source: Bain ENR Transition Survey 2023 (n=608)

Reduction of Scope 1 and 2 emissions remains the top ESG priority for energy and natural resource companies (88% rank emissions reduction in their top three issues). ENR executives are also thinking about their impact on local communities, a point that remains a top-three issue in all regions other than Europe, where it ranks below Scope 3 emissions and circularity *(see Figure 3)*. Interest in circularity is also growing. In the chemicals sector, it's a top-two priority, and we've seen an 8- to 10-percentage-point increase in interest in agribusiness, mining, and oil and gas, where roughly one in three executives consider it a top-three priority.

Four out of five executives consider the ability to create acceptable returns on projects a main barrier to decarbonization of the energy system. Their concerns are based on customers' unwillingness to pay—not universal, but enough to make it hard to scale low-carbon businesses. So they look to government policy and regulatory support to help bridge the gap. Fewer than 20% expressed significant concerns about accessing capital *(see Figure 4)*.

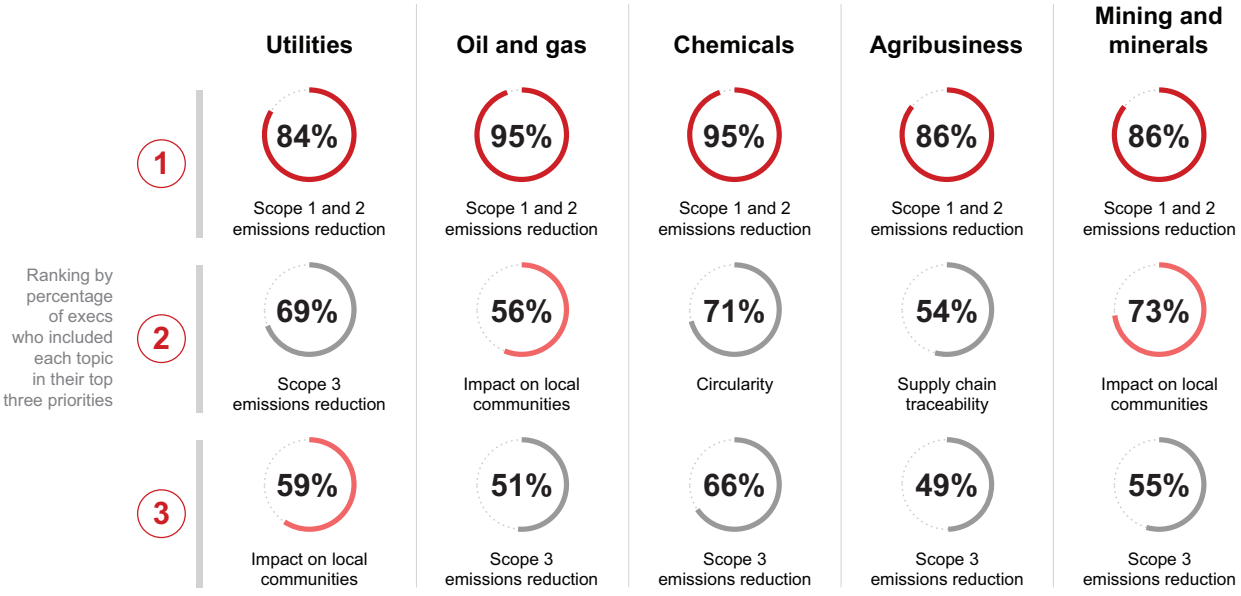
Figure 2: On average, executives expect emissions reductions to reflect current pledges until 2030, then accelerate to achieve net zero by 2057

Global greenhouse gas emissions ($GtCO_2$)



Note: Baseline estimate from Climate Action Tracker December 2018 update
Sources: Climate Action Tracker, November 2021; IEA; Bain ENR Transition Survey 2023 (n=608)

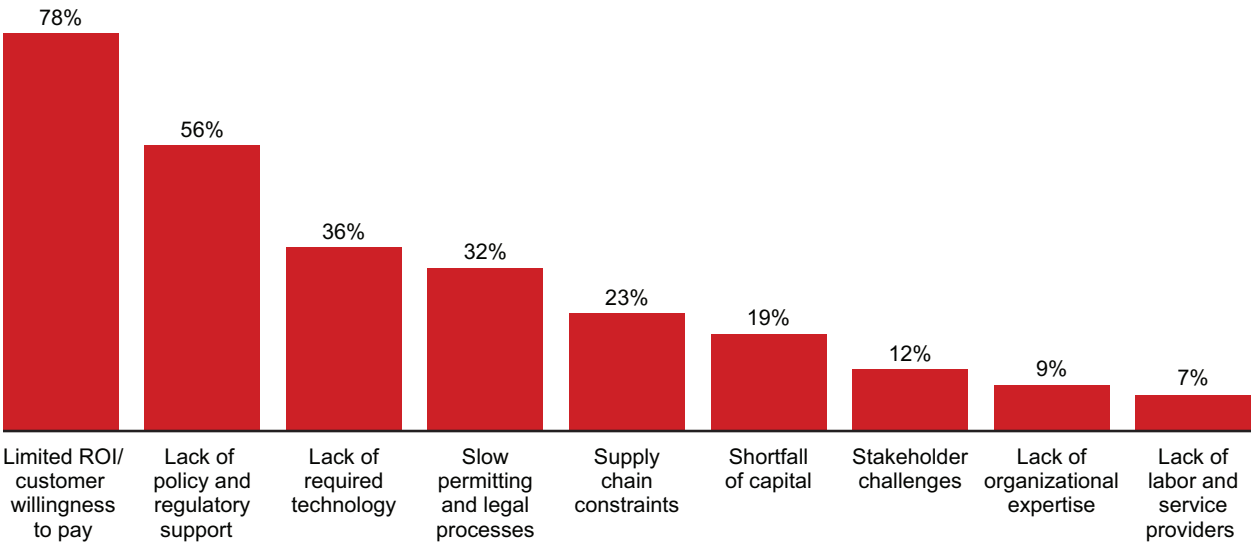
Figure 3: Emissions reduction and the impact on local communities remain top concerns across ENR industries



Notes: Scope 1 measures greenhouse gases directly emitted by an organization or by activities under its control; Scope 2 measures indirect emissions from electricity or other power used by an organization; Scope 3 measures other indirect emissions related to an organization, including those resulting from the use of its products
Source: Bain ENR Transition Survey 2023 (n=608)

Figure 4: Executives say the greatest obstacles to decarbonization are customers' unwillingness to pay higher prices and the difficulty of ensuring adequate returns for investments

Percentage of executives who selected each barrier in their top three



Source: Bain ENR Transition Survey 2023 (n=608)

"Transition will not occur if it has a negative impact on companies' economic bottom line. Companies cannot transition if their businesses are at risk by doing so."

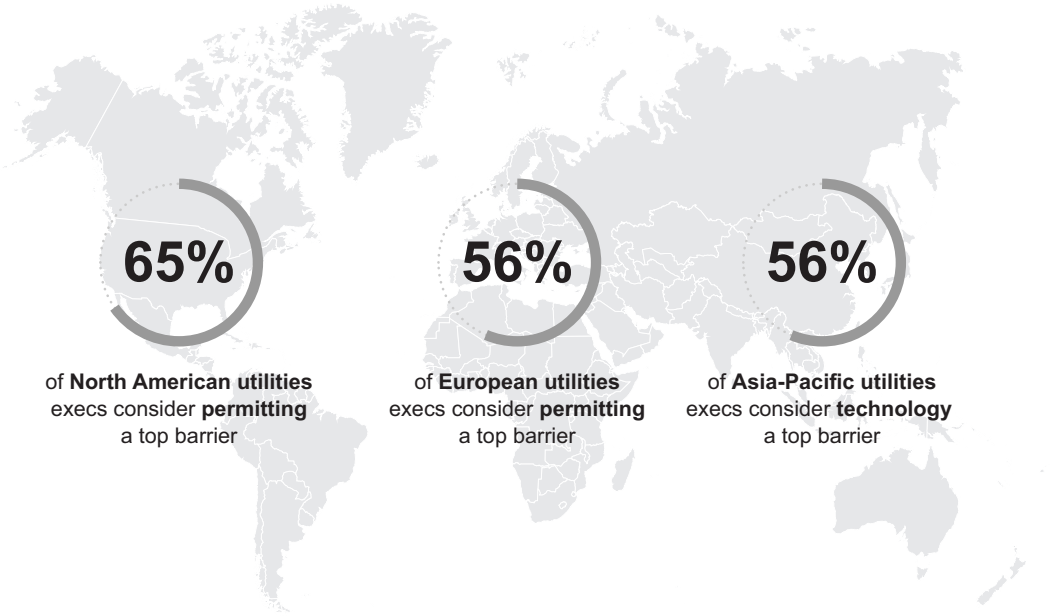
—Mining and minerals executive, Latin America

Slow permitting is also a major concern, even where the policy environment is more accommodating. Most North American utilities executives cited it as one of their top concerns, although they also see policy as much less of a barrier than do their counterparts in Europe and Asia *(see Figure 5)*. In Europe, where more than half of executives from the utilities and mining sectors cite slow permitting as a top issue, the European Union has announced a draft regulation that aims to reduce permitting times for large energy transition projects to no more than 12 months.

"While it can be a worthy goal to cut emissions, there will be a large societal cost if we move too quickly in the short term and leave people at risk of dying because they can't afford to heat their homes."

—Utilities executive, United States

Figure 5: North American and European utilities executives are concerned about permitting; executives in Asia-Pacific see technology as a top barrier



Source: Bain ENR Transition Survey 2023 (n=608)

Surprisingly, not many executives identified service providers (e.g., engineering, procurement and construction contractors, as well as maintenance companies) as a bottleneck. Only 7% flagged it as a major problem, possibly because many decarbonization projects are still at early stages with only limited capital deployed so far.

In the Asia-Pacific region, availability of technology also shows up as a critical barrier.

"The complications in developing economies is the reliance on the core businesses for provision of labor and economic opportunities which may not be replicated in the energy transition."

—Chemicals executive, Africa

Other executives expressed concerns about price spikes if fossil fuels are defunded too quickly and energy supply cannot meet demand. Some also described a lack of understanding on the part of policymakers, the media, and the public about the interconnectedness of the energy system, and they look to governments to help determine realistic paths and goals.

"There is a basic lack of understanding of how a fully decarbonized system may work and at which cost. Policymakers yearly increase decarbonization targets, without any reality check. Top-down processes are predicted to fail unless they find support from people, especially when these targets erode spending power by increasing the cost of energy and fuels."

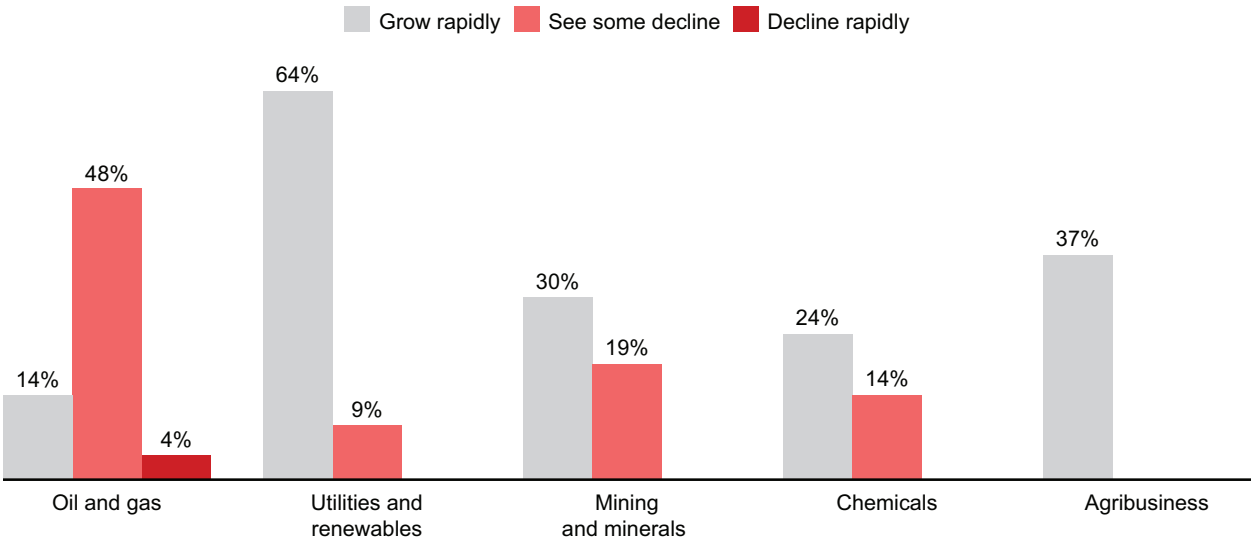
—Utilities executive, Europe

Prospects for core businesses

Events of the past year show no significant effect on executives' beliefs about the durability of their core businesses. Executives in utilities and new energy are most optimistic, with nearly two-thirds expecting their business to grow rapidly, owing to continued tailwinds from electrification and low-carbon energy increasingly a part of their core business. The percentage of oil and gas executives anticipating a rapid decline of their core business over the next 10 years fell to 4% from 8% the previous year. But, as last year, about half still expect some decline *(see Figure 6)*.

Figure 6: Oil and gas executives are less sanguine about the prospects of their core business than their peers in other ENR industries

Share of executives who think that, over the next 10 years, their core business will...



Note: No respondents for agribusiness expect a decline
Source: Bain ENR Transition Survey 2023 (n=608)

Capital for low-carbon business. ENR companies plan to allocate more capital to new, low-carbon growth areas. Across sectors, they plan to allocate about 24% of their capital to new growth businesses in 2023, up from 16% in 2020, consistent with the trend we saw last year *(see Figure 7)*.

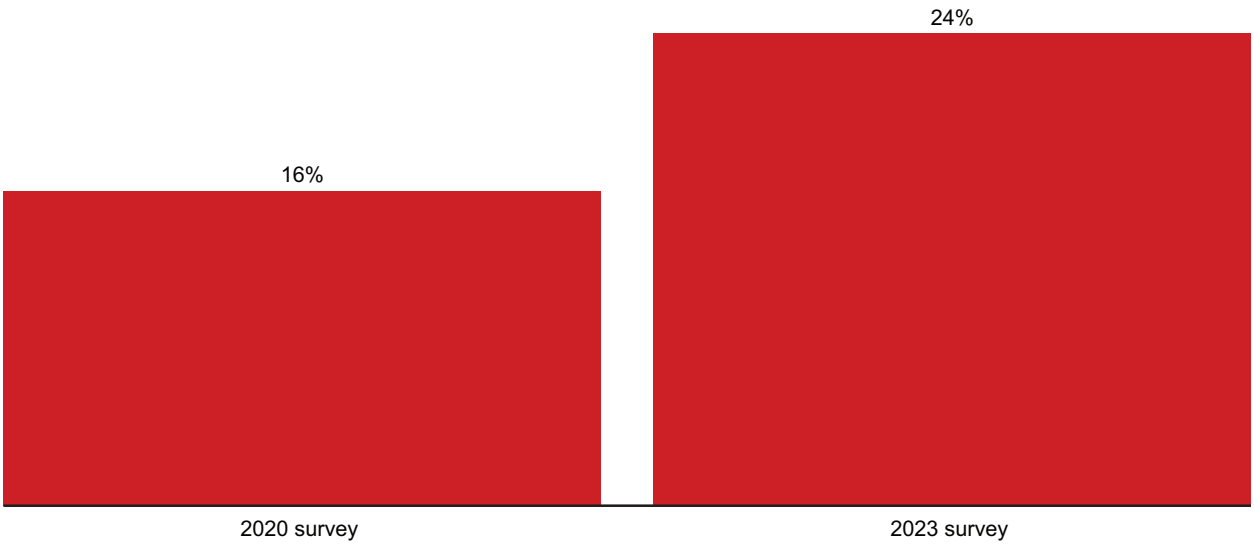
Regionally, North America is catching up with Europe due to incentives included in the US's Inflation Reduction Act (IRA)—an early indication of how quickly companies can react to positive policy signals *(see Figure 8)*. As a result, some executives in other regions expressed concerns about competitiveness and the need for equivalent policy support in other countries.

"In the transition process towards a more sustainable industry, policymakers must make sure that Europe can maintain its competitiveness vs. other regions that do not apply the same environmental standards."

—Chemicals executive, Europe

Across sectors, executives expected about the same levels of capex investment, except in mining, where expectations increased significantly, possibly in response to rising demand for transition minerals like copper, nickel, and lithium *(see Figure 9)*.

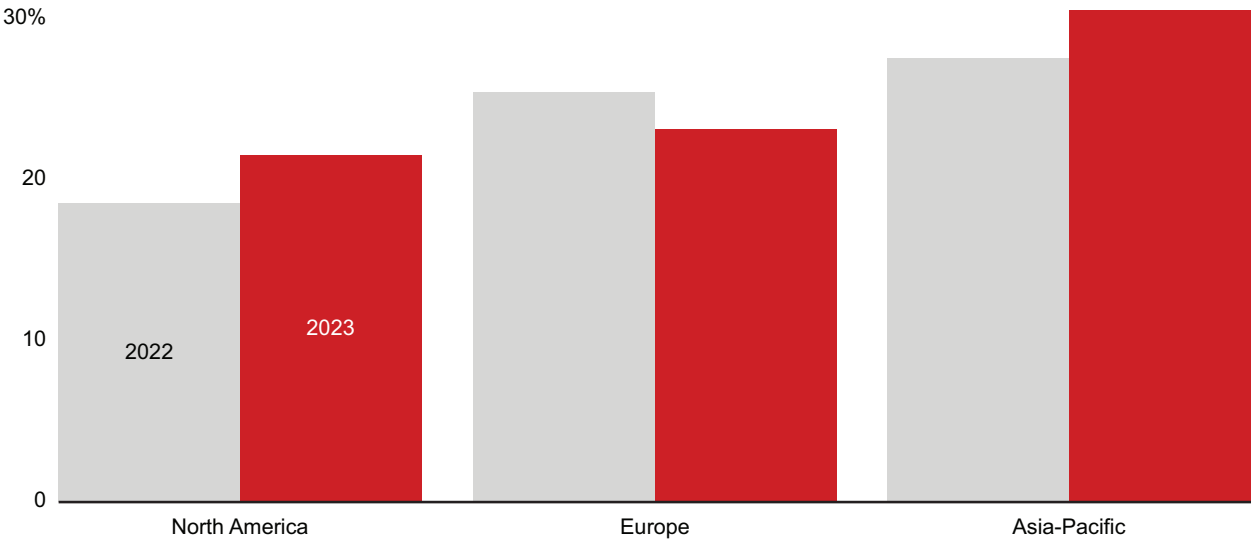
Figure 7: Companies continue to increase their capex allotment to new, low-carbon growth areas



Sources: Bain ENR Transition Survey 2020 (n=81); Bain ENR Transition Survey 2023 (n=608)

Figure 8: Government policy changes may have spurred growth in North American low-carbon investments

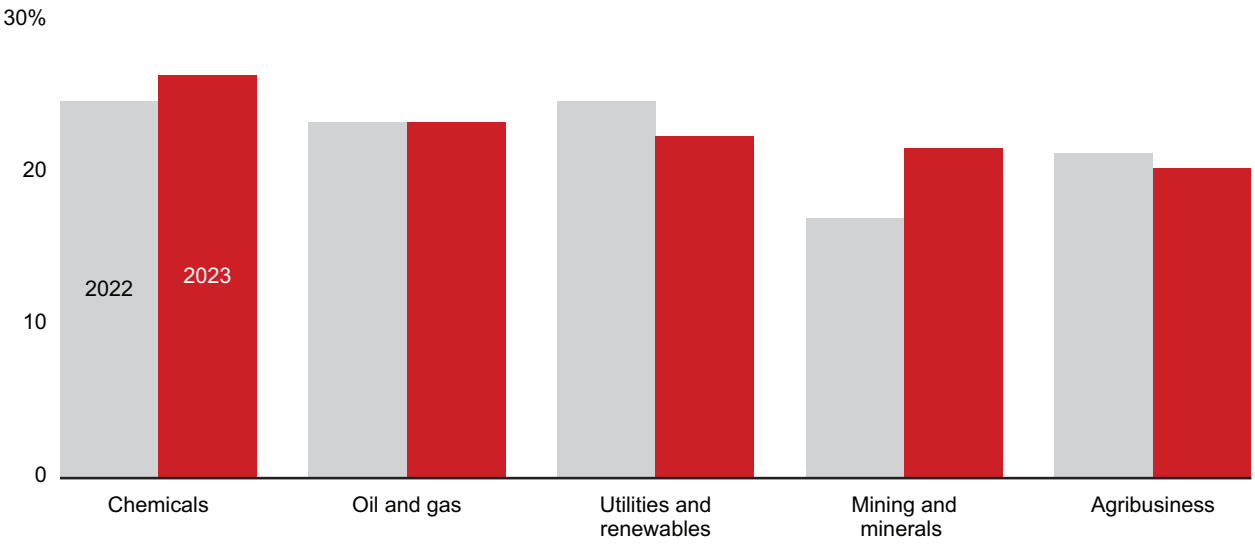
Expected share of capex allocated to new growth areas



Sources: Bain ENR Transition Survey 2022 (n=1,037); Bain ENR Transition Survey 2023 (n=608)

Figure 9: Capex allocation to new growth areas across industries is fairly consistent with last year, except for a notable increase in mining and minerals

Expected share of capex allocated to new growth areas



Sources: Bain ENR Transition Survey 2022 (n=1,037); Bain ENR Transition Survey 2023 (n=608)

New technologies. As they did last year, executives believe the three most important technologies for 2030 will be renewables, digital, and energy storage. By 2050, they expect hydrogen to replace digital as a key technology, with more than four in five believing it will have a significant impact on their business. We found other notable spikes by region and sector *(see Figure 10)*.

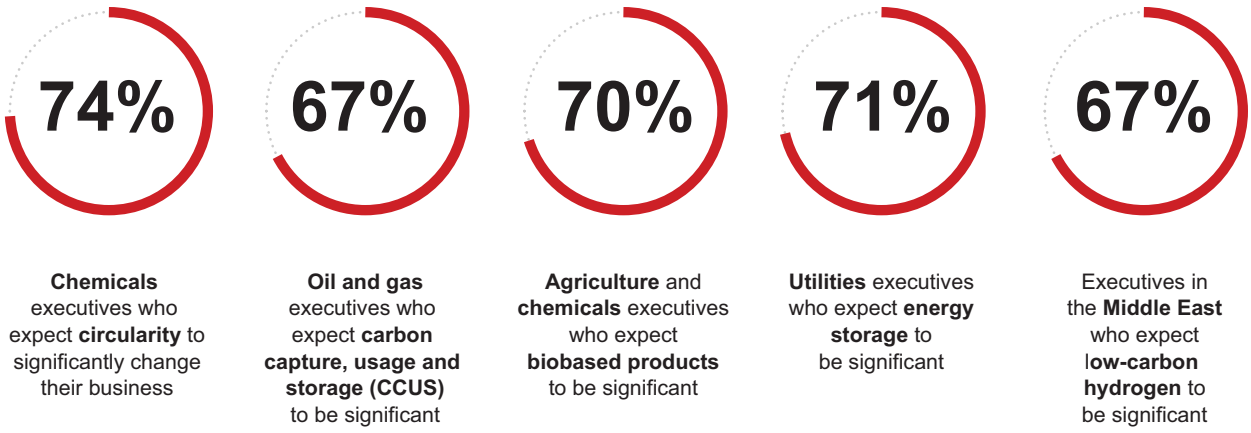
Scaling new businesses. Executives remain confident that their low-carbon businesses will become significant by 2030, with 70% expecting these businesses to account for more than 10% of company profits or valuation by 2030 *(see Figure 11)*. We see some variation by sector. For example, executives in mining and minerals raised their expectations significantly this year, whereas oil and gas execs showed a bit less optimism in the prospects for their new, low-carbon businesses, perhaps due to improved medium-term prospects for their legacy ones.

"[The energy transition] is something essential for survival, and it will arrive sooner than expected."

—Oil and gas executive, South Korea

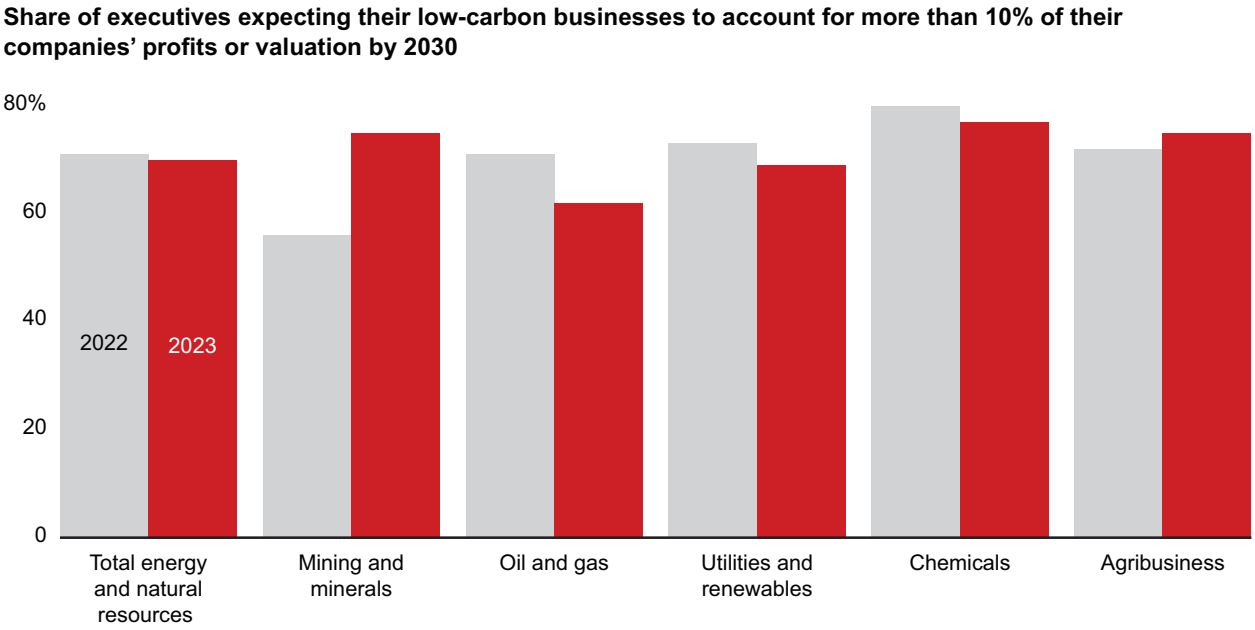
However, scaling low-carbon businesses remains extremely challenging. Executives told us that the roadblocks are less about bold ambition and company culture and more about building a scalable

Figure 10: Across sectors, executives expect different technologies to matter most by 2030



Source: Bain ENR Transition Survey 2023 (n=608)

Figure 11: Expectations are high for the contributions of new, low-carbon businesses by 2030



Sources: Bain ENR Transition Survey 2022 (n=1,037); Bain ENR Transition Survey 2023 (n=608)

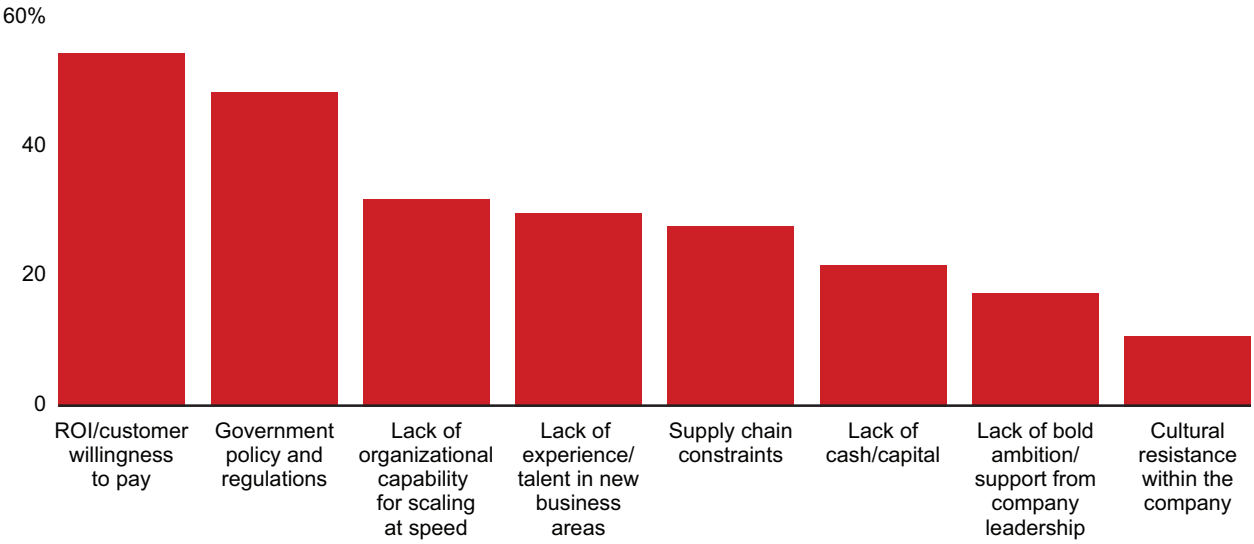
model that delivers acceptable returns *(see Figure 12)*. (For more on the early lessons from Engine 2 buildouts, read the Bain Brief "How to Do Engine 2 for the Energy Transition.")

Return on investment remains a significant challenge for individual companies, which they are addressing by being more selective and focusing on opportunities that generate acceptable returns. Maintaining those acceptable returns while scaling new growth businesses remains difficult since most customers are unwilling to pay higher prices for essential mass market goods and services. Government policy and regulatory support are critical to develop and grow these markets. Investors may also need to reconsider their capital allocation strategies in order to fund the lower-risk, lower- return investments needed in some new low-carbon businesses. Companies also cite uncertainty about access to talent and organizational capabilities as serious impediments to growth.

While **government policy and permitting** remain the predominant roadblocks to the growth of new, low-carbon businesses in the sector, our survey revealed regional nuances. For example, almost twice as many European oil and gas executives blamed policy uncertainty for delayed investment decisions, compared with the previous year (61% vs. 36% in 2022), while fewer executives in North America assigned similar blame (50% vs. 59%), possibly showing the effects of the IRA *(see Figure 13)*.

Figure 12: Executives are less concerned about internal constraints, more concerned about government policy and building viable businesses

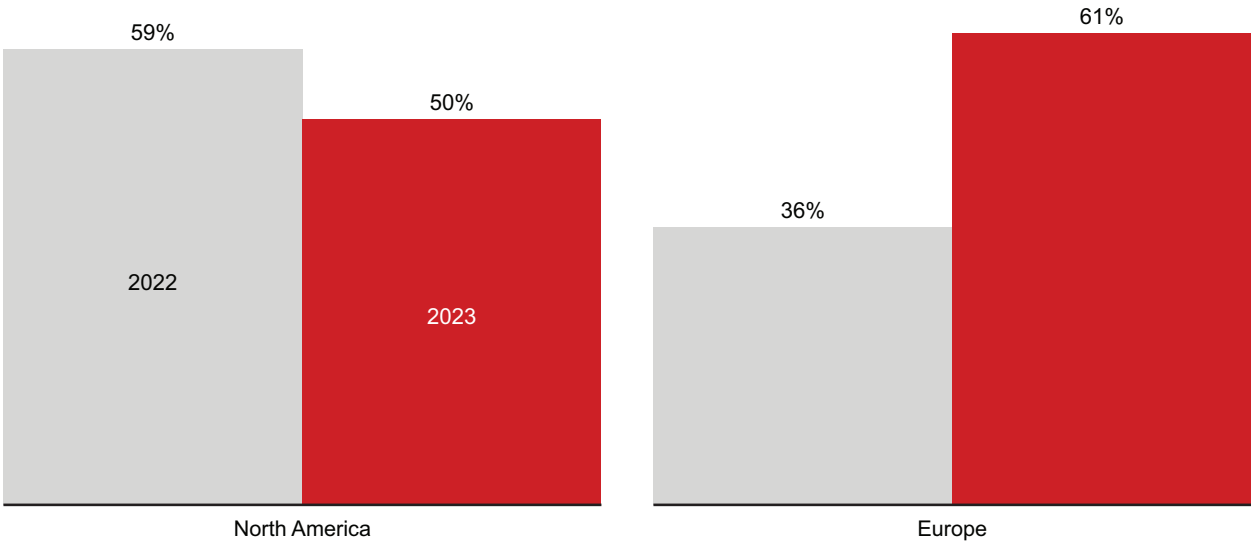
Share of executives who consider each factor to be a very significant roadblock to scaling their low-carbon growth businesses



Source: Bain ENR Transition Survey 2023 (n=608)

Figure 13: Views on policy uncertainty shifted among North American and European oil and gas executives

Share of oil and gas executives who believe that uncertainty over future government policies is delaying investment in new business areas



Sources: Bain ENR Transition Survey 2022 (n=1,037); Bain ENR Transition Survey 2023 (n=608)

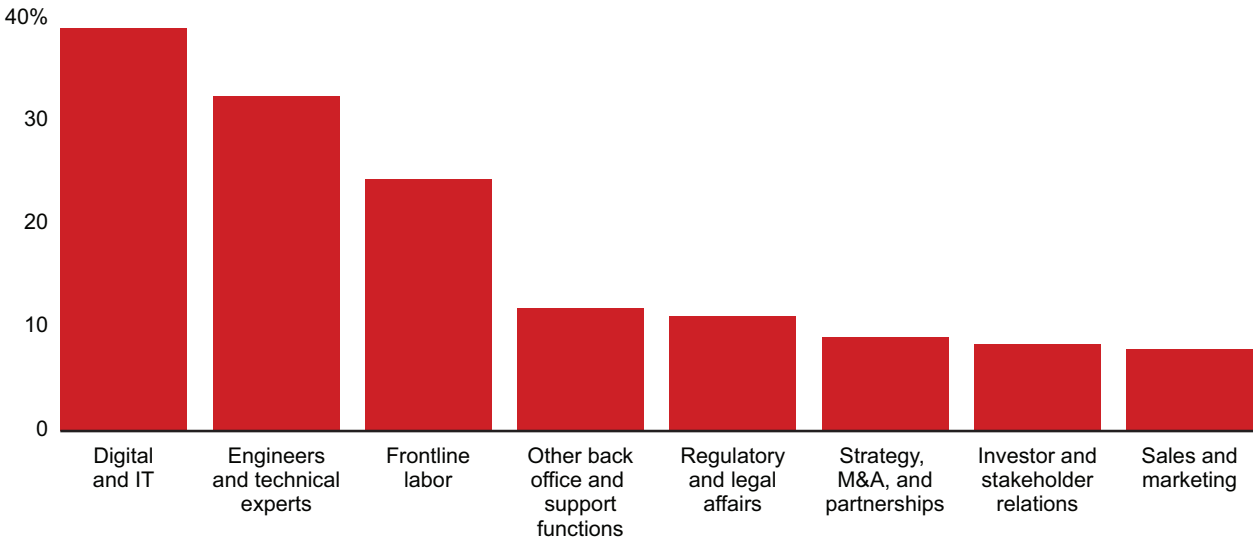
Building organizational capabilities and finding talent remain major challenges for growing low- carbon businesses, especially in several key roles *(see Figure 14)*. Digital and information technology talent is at a premium in all sectors and regions. About 60% of executives expect digital and AI technologies to change their businesses significantly by 2030, but they're struggling to find talent that can help them manage the change. In addition, about one in three companies report difficulty finding the engineers they need, and one in four are having trouble hiring frontline workers.

The situation is more acute in North America, where 39% of companies are having difficulty finding frontline labor *(see Figure 15)*. Talent is the top roadblock to scaling growth businesses in the Middle East, where 42% of companies have difficulty finding frontline workers and 33% have trouble finding sales and marketing talent. The market for frontline workers appears much more favorable in Latin America and Asia.

A final point of concern is the issue of resilience. Our survey found executives confident or very confident about their company's resilience to the physical effects of climate change—though whether this confidence is justified remains to be seen *(see Figure 16)*. Observing the industries in the energy and natural resource sectors, we believe that risks to physical assets may be greater than many companies anticipate, and these risks haven't been fully factored into their planning and capital deployment.

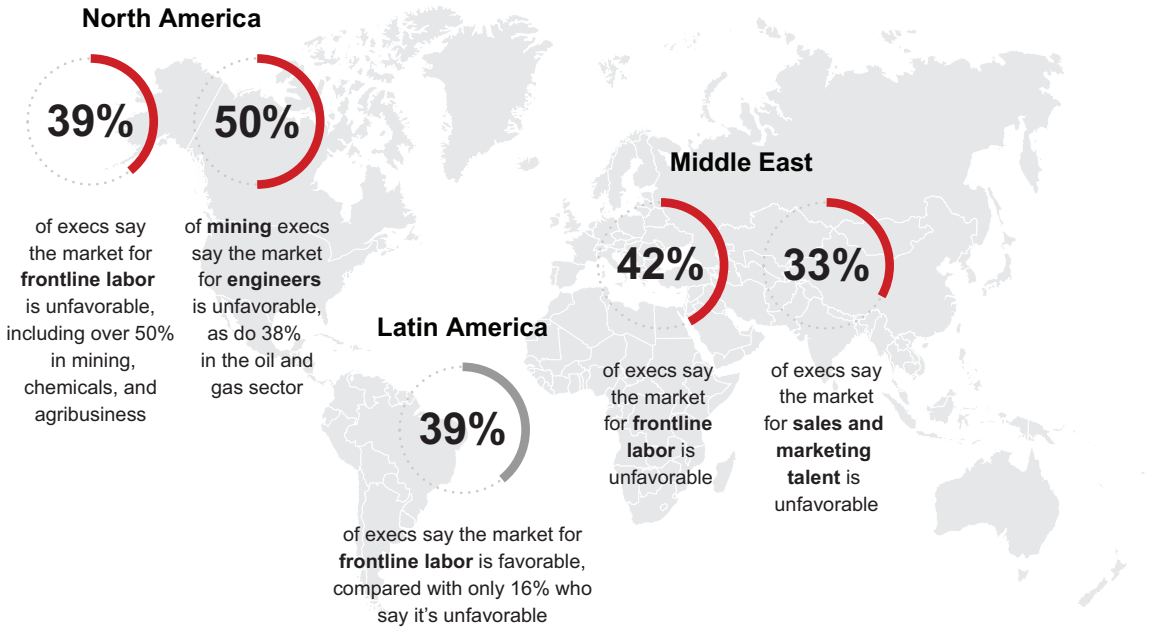
Figure 14: Digital, engineering, and other technical roles remain the toughest to fill, with frontline labor increasingly difficult

Share of executives who cite an unfavorable environment for finding and keeping talent in these roles



Source: Bain ENR Transition Survey 2023 (n=608)

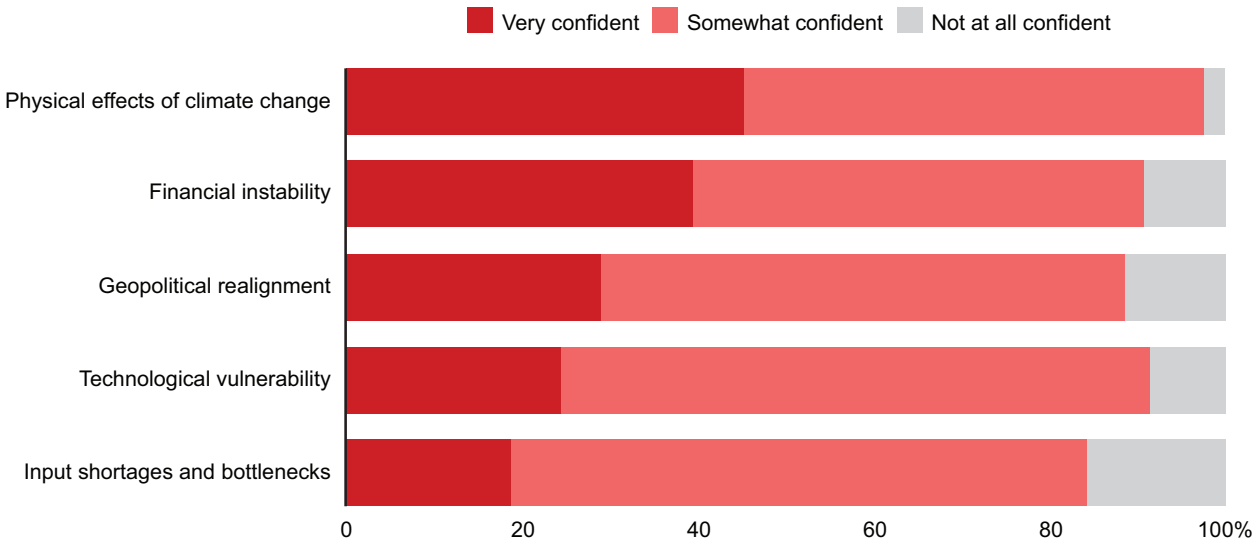
Figure 15: Labor market challenges vary by region



Source: Bain ENR Transition Survey 2023 (n=608)

Figure 16: Executives are most confident about their organizations' physical resilience

Executives' level of confidence regarding resilience of their company to different factors

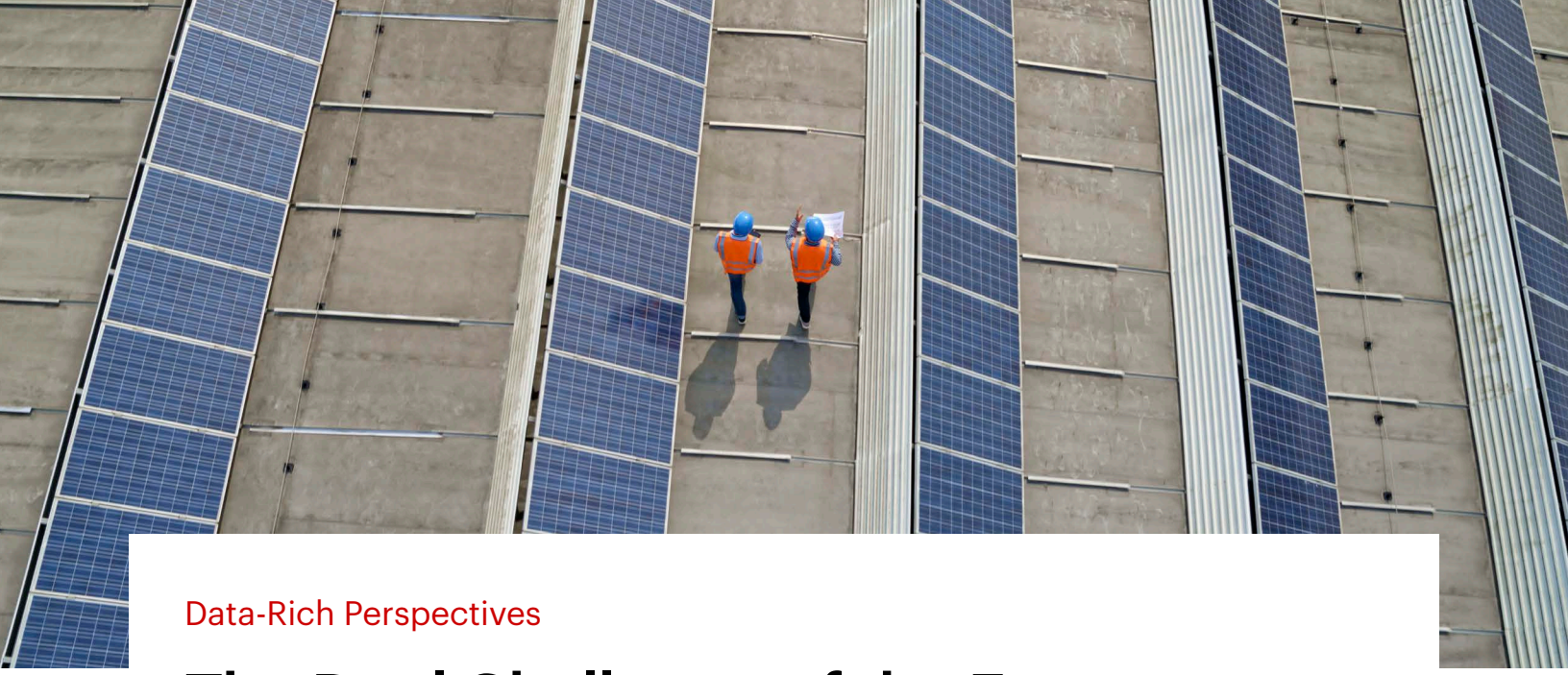


Source: Bain ENR Transition Survey 2023 (n=608)

In other aspects of resilience, executives are more concerned. For example, fewer than one in five are very confident of their resilience to supply chain bottlenecks, which are likely to become even more acute as new businesses with new supply demands (for example, new feedstocks for recycling or biofuel) attempt to scale.

Observing the industries in the energy and natural resource sectors, we believe that risks to physical assets may be greater than many companies anticipate, and these risks haven't been fully factored into their planning and capital deployment.

While energy and natural resource executives see real challenges in policy, permitting, talent, and scaling new businesses that can generate acceptable returns, they remain committed to steadily increasing capital deployment and playing their part in the world's bumpy journey to net zero by the late 2050s.



Data-Rich Perspectives

The Dual Challenge of the Energy Transition Is Urgent and Unprecedented

Meeting the growing demand for energy while also reducing greenhouse gas emissions is the central challenge of the 21st century.

By James Baird, Torsten Lichtenau, Alessandro Cadei, and Prashant Sarin

At a Glance

- Energy security has moved up the global agenda over the past 18 months, magnifying the trade-offs and complexities involved in navigating the energy transition.
- The tension between energy supply and climate change presents a dual challenge for the 21st century: breaking the historical link between energy and greenhouse gas emissions.
- Solving the challenge will require change on an unprecedented scale and pace, including major infrastructure investments. By one measure, the world needs to nearly triple annual investment in clean energy to reach net-zero emissions by 2050.
- Energy and natural resource companies are and will continue to be at the center of every aspect of the transition to come.

The war in Ukraine and ensuing disruption to the global energy system have reminded us all that affordable, reliable energy is the foundation upon which modern civilization rests. From the electricity used to light our homes, to the liquid fuels powering cars and planes, to the energy needed to produce fertilizer for growing our food, energy is integral to everything we do.

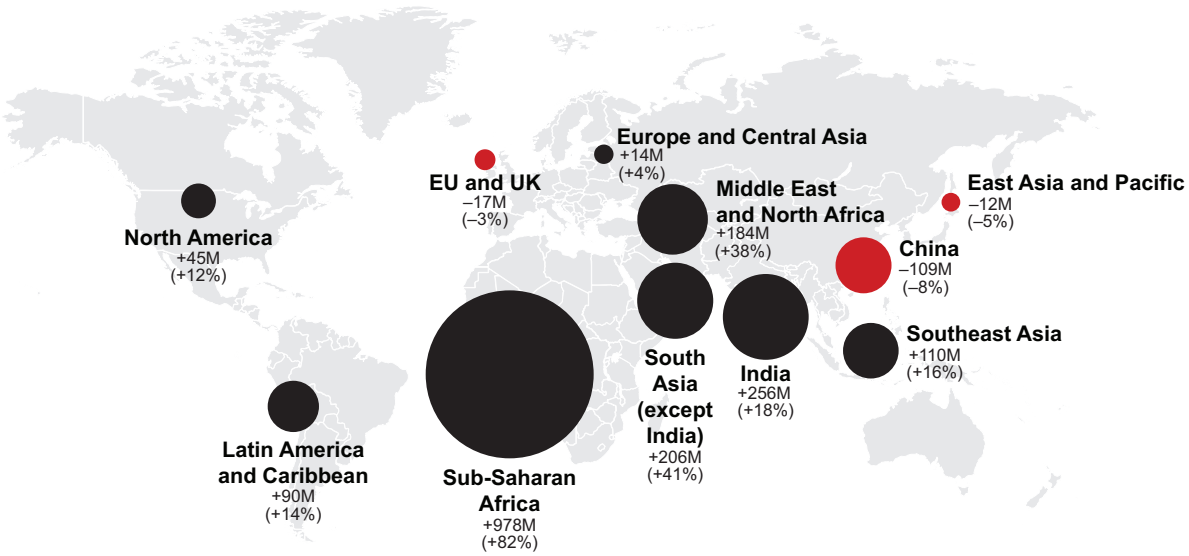
The massive expansion of primary energy supply since the 19th century has driven an unparalleled improvement in human longevity and prosperity. However, those benefits haven't been equally distributed. There is still considerable energy poverty, concentrated primarily in the Global South. About 675 million people lack access to electricity, and 2.3 billion people—almost 30% of the world's population—don't have access to clean cooking fuels and technologies that prevent premature death from indoor air pollution. Future population growth will be overwhelmingly concentrated in these regions, with the population of sub-Saharan Africa alone expected to almost double *(see Figure 1)*.

The world needs more energy.

Yet our largest primary energy sources, fossil fuels, are also the largest sources of anthropogenic greenhouse gas emissions. Fossil fuels account for around 80% of our primary energy supply, and our reliance on them has not changed appreciably in 30 years. Rising greenhouse gas concentration in the atmosphere, produced in large part by the production and combustion of fossil fuels, is causing

Figure 1: The global population is expected to increase by 1.7 billion by 2050, mostly in the Global South

Population growth between 2022 and 2050



Sources: UN World Population Prospects 2022 (medium fertility variant); BP Statistical Review of World Energy 2022; World Bank; EIA; Bain analysis

the planet to warm, and there is now clear scientific consensus that adverse consequences for human prosperity and well-being will result if this warming trend continues.

The tension between energy supply and climate change presents a dual challenge for the 21st century. How will the world increase energy supply while simultaneously curbing emissions?

The scale and pace of change required to solve the challenge are unprecedented and extraordinary. By one well-known measure, the IEA's Net Zero Emissions by 2050 Scenario, the world would need to approximately double its 2022 pace of total energy investment by 2030 and sustain this level, or slightly lower, through 2050 to achieve net-zero emissions. This includes nearly tripling annual investment in clean energy.

The tension between energy supply and climate change presents a dual challenge for the 21st century. How will the world increase energy supply while simultaneously curbing emissions?

Many energy and natural resource executives are acutely aware of these realities. But as energy security has moved up the global agenda over the past 18 months, the difficult road ahead for the energy transition has become even clearer.

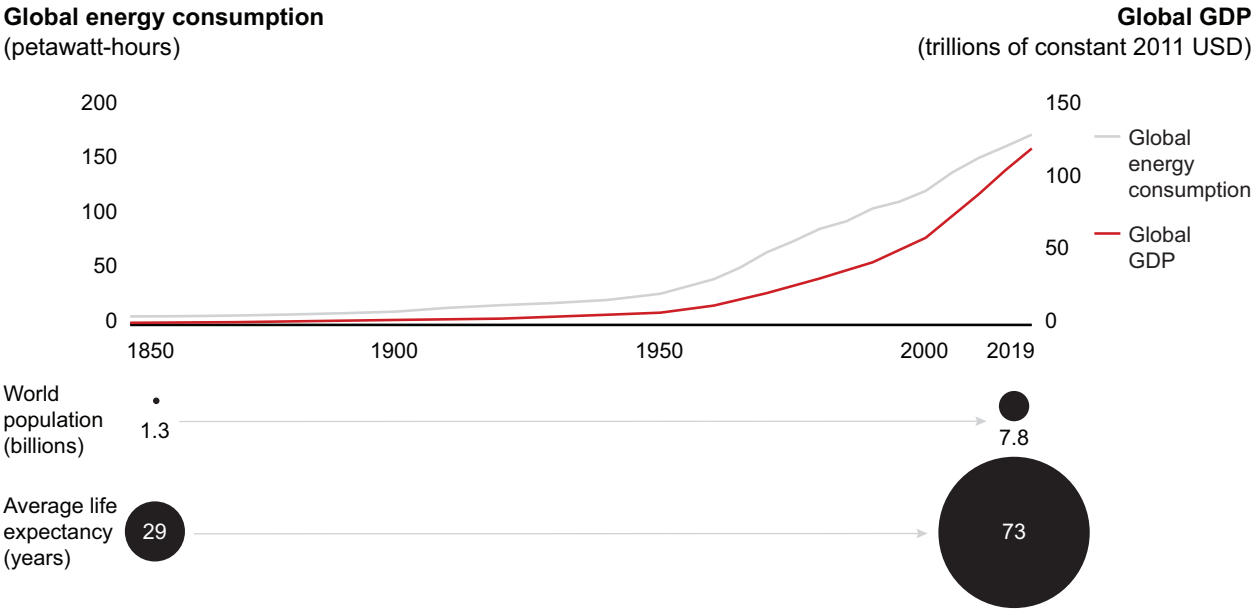
Energy and natural resource companies are and will continue to be at the center of every aspect of the unfolding transition, and how these companies navigate the accompanying opportunities and risks will have major implications for how the dual challenge ultimately plays out. (Read the next chapter of the report for more detail.)

The need for more energy

The world must increase its energy supply to support human well-being and economic growth. Historically, global energy consumption, population, and gross domestic product have grown in tandem *(see Figure 2)*. In less mature economies, small increases in energy consumption per capita are strongly associated with significant gains in the Human Development Index, a United Nations composite measure comprised of indicators for health, education, and income—supporting the notion that energy is critical to human prosperity.

Despite substantial growth in the world's energy supply over the last 150 years, billions of people still don't have access to enough affordable, reliable energy. Population growth over the next three decades will be overwhelmingly concentrated in these regions. Their populations and governments will continue to focus on expanding their energy supplies—including electricity generation and

Figure 2: Global energy use has always grown with the population and GDP



Note: GDP is adjusted for purchasing power parity
Sources: BP Statistical Review of World Energy 2021; Vaclav Smil, *Energy Transitions: Global and National Perspectives*, 2017; Maddison Project Database 2020, Jutta Bolt and Jan Luiten van Zanden, "Maddison style estimates of the evolution of the world economy: A new 2020 update"; World Bank; Our World in Data; Bain analysis

infrastructure, among other areas—to support economic development and improve living standards *(see Figure 3)*.

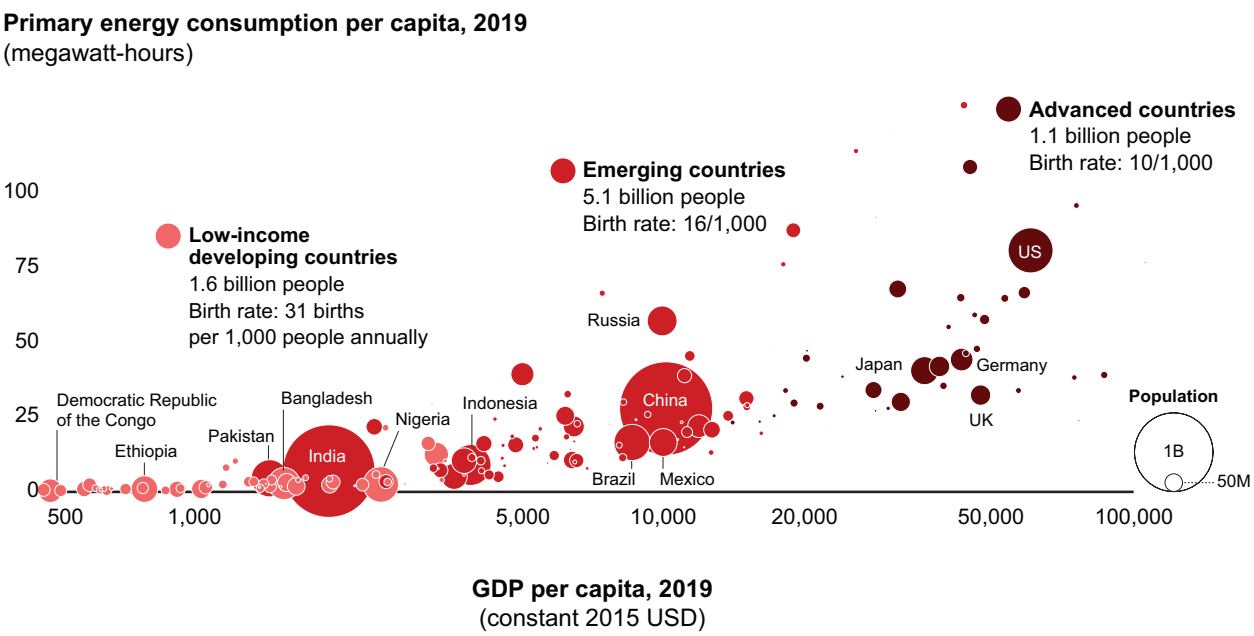
To put the need for increasing the world's energy supply in even starker terms, consider the following thought experiment. Say that India, Indonesia, Pakistan, Nigeria, and other countries with low or very low energy consumption per capita today were to increase per capita consumption by 2050 to the level of, for example, Mexico in pursuit of economic growth, a desirable goal. Global primary energy consumption would then grow by about 70 petawatt-hours, or approximately 45% of total global energy supply as of 2019.

Efficiency gains, including from electrification and increased renewable energy use, will offset some of the future demand. So far, however, only advanced economies comprising a minority of the global population have decoupled economic growth from energy consumption *(see Figure 4)*.

Consequences of business as usual

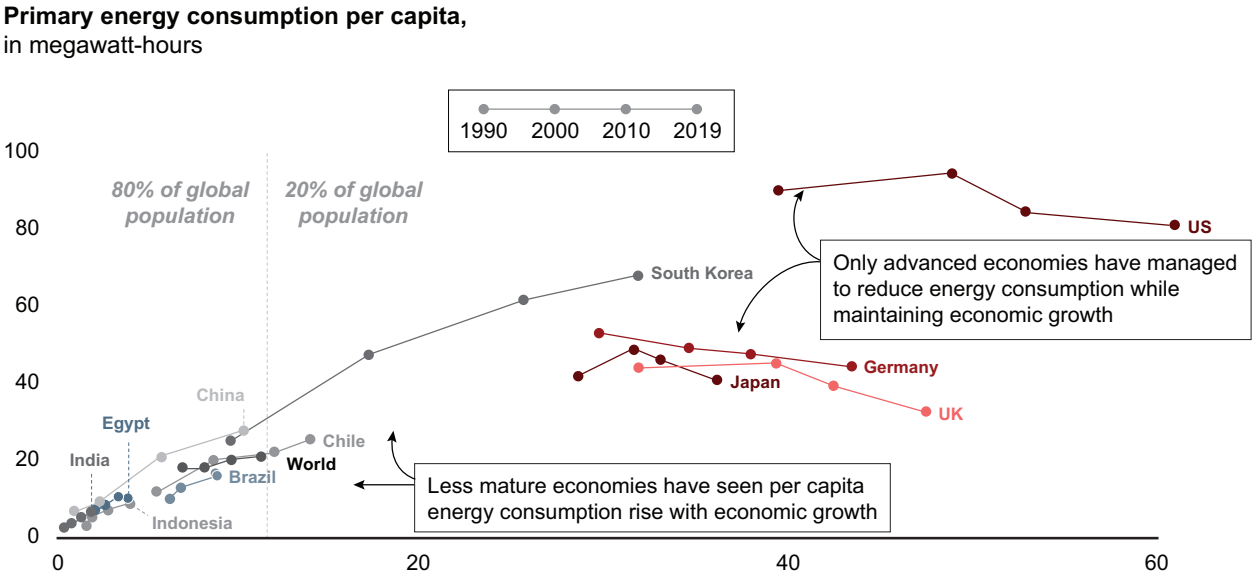
Absent action both to decarbonize our existing energy supply and to avoid further emissions as developing economies advance, significant risks emerge—and these risks aren't uniformly shared across the world.

Figure 3: Energy consumption is correlated with economic progress, and there is still considerable inequality



Notes: GDP per capita is shown on a logarithmic scale; country categorization reflects IMF economy classification system
Sources: World Bank; IMF; BP Statistical Review of World Energy 2022; EIA; UN World Population Prospects 2019; Our World in Data; Bain analysis

Figure 4: So far, only advanced economies have decoupled economic growth from energy consumption



Sources: World Bank; BP Statistical Review of World Energy 2022; EIA; IMF; Bain analysis

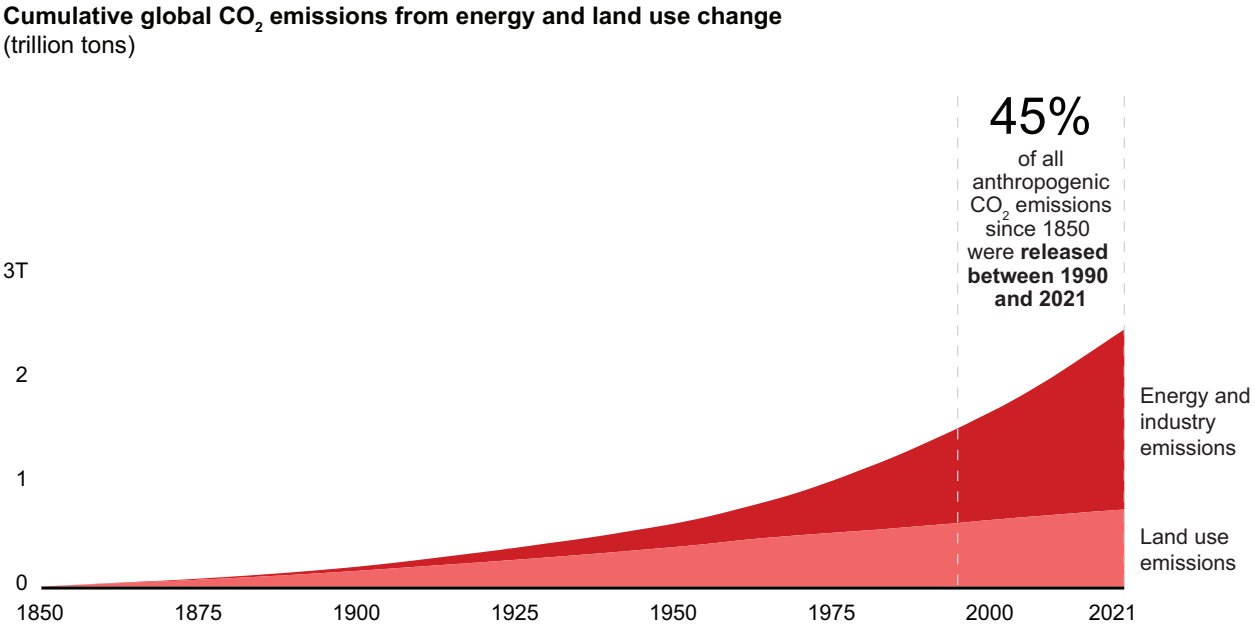
As human-induced climate change is principally a function of the atmospheric concentration of gases like carbon dioxide, the cumulative emissions total over a period of decades matters. Human activity has caused the release of more than 2 trillion cumulative tons of carbon dioxide worldwide since 1850, and about 45% of that was emitted between 1990 and 2021 *(see Figure 5)*.

It's worth noting that the world has made some progress toward climate targets in recent years. After the Paris Agreement in 2015 and ensuing policy commitments by national governments, the temperature estimates for end-of-century warming had fallen by around a half-degree Celsius as of 2020. Still, global CO2 emissions from fossil fuels reached a new high in 2022, and there's no sign that emissions have peaked.

Warming caused by human activity has already produced adverse impacts on both natural and human systems, including increased food and water insecurity; damage to terrestrial, freshwater, coastal, and ocean marine ecosystems; and species losses. Continued warming will very likely lead to higher frequency and intensity of certain types of extreme weather, such as extreme heat events, heavy precipitation events, and severe agricultural or ecological droughts.

What's more, future risks aren't uniformly distributed, with Southeast Asia and sub-Saharan Africa disproportionately exposed to the negative consequences *(see Figure 6)*.

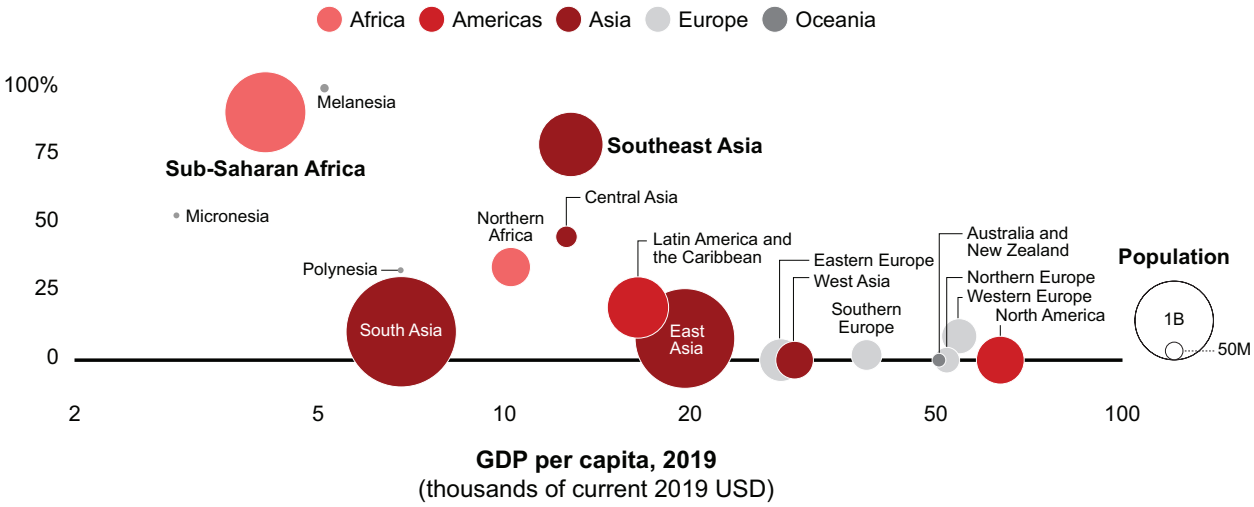
Figure 5: Human activity has caused the release of more than 2 trillion cumulative tons of CO_2 since 1850



Note: Excludes non-CO_2 emissions such as methane
Sources: Global Carbon Project; Our World in Data; Bain analysis

Figure 6: Future climate change risk varies considerably by region, with Southeast Asia and sub-Saharan Africa disproportionately exposed

Share of population at high or very high risk



Notes: Share of population at risk based on the WorldRiskIndex, which assesses the risk of disaster as a result of natural hazards, incorporating exposure and vulnerability, and is used by the IPCC to gauge region- and country-level climate change risks; GDP per capita is shown on a logarithmic scale and is adjusted for purchasing power parity
Sources: IPCC, Sixth Assessment Report; World Risk Report 2021; World Bank; Bain analysis

The pace and frictions of change

Avoiding the worst risks of climate change will require the world to reduce and eventually eliminate greenhouse gas emissions produced by human activity. Scenarios in which the average increase in global surface temperature is held below 2 degrees Celsius by 2100 imply massive, nearly immediate, and sustained emissions reductions; by 2050, the level of anthropogenic greenhouse gas emissions would need to be at least 60% lower than it is today.

Achieving this would necessitate substantial, rapid changes to our energy system, which is responsible for about three-quarters of anthropogenic greenhouse gas emissions. Doing this in 27 years would be unprecedented. History suggests turning over even one-quarter of the global energy supply takes at least three decades, reflecting the asset intensity of the energy system. It's notable that each time the world transitioned to a new primary energy source, from coal to crude oil to natural gas, the displaced primary fuel source didn't disappear. In fact, the quantity of primary energy supplied by coal, oil, and gas is today at or near all-time highs.

The physical scale of what must be addressed is hard to comprehend. Consider, as one example, our energy production and processing infrastructure, which is capable of handling more than 15 billion

tons of coal, oil, and gas extraction, processing, and distribution each year. This infrastructure includes an oil and gas pipeline system that, if lined up end to end, would wrap around Earth nearly 30 times.

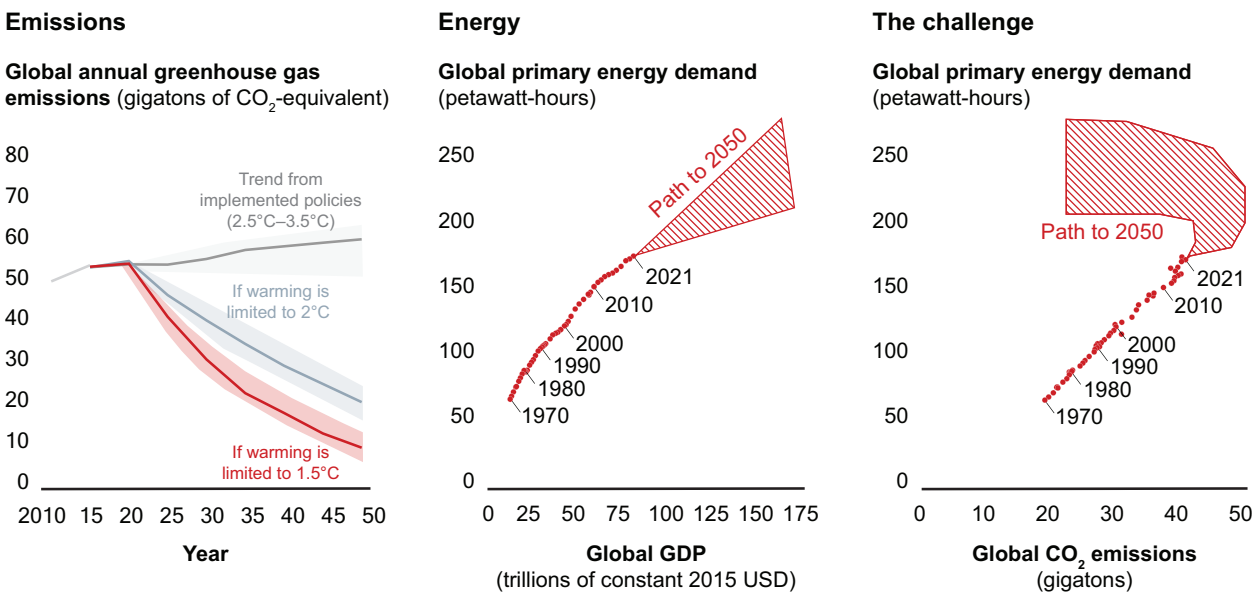
Unsurprisingly, the amount of capital required to replace, repurpose, or otherwise mitigate the warming impact of our energy system so quickly is enormous. And that doesn't include the significant capital required to build entirely new energy infrastructure to support rising demand in places currently experiencing energy poverty. In our view, very few components of the energy system are prepared for change at the scale and pace required.

Defining the tension

Putting these elements together, a picture emerges of the extraordinarily challenging path we must take to resolve the dual challenge *(see Figure 7)*.

First, it's imperative that the world reduce anthropogenic greenhouse gas emissions to limit the negative impacts of climate change, but we're not on track for a scenario in which the world warms less than 2 degrees Celsius above preindustrial levels (see first panel in the chart below). At the same time, energy supply will likely need to increase in the coming decades to support economic growth and enhance human well-being, though efficiency gains will provide some buffer (see second panel).

Figure 7: Solving the dual challenge will require expanding affordable, reliable energy access while simultaneously reducing emissions

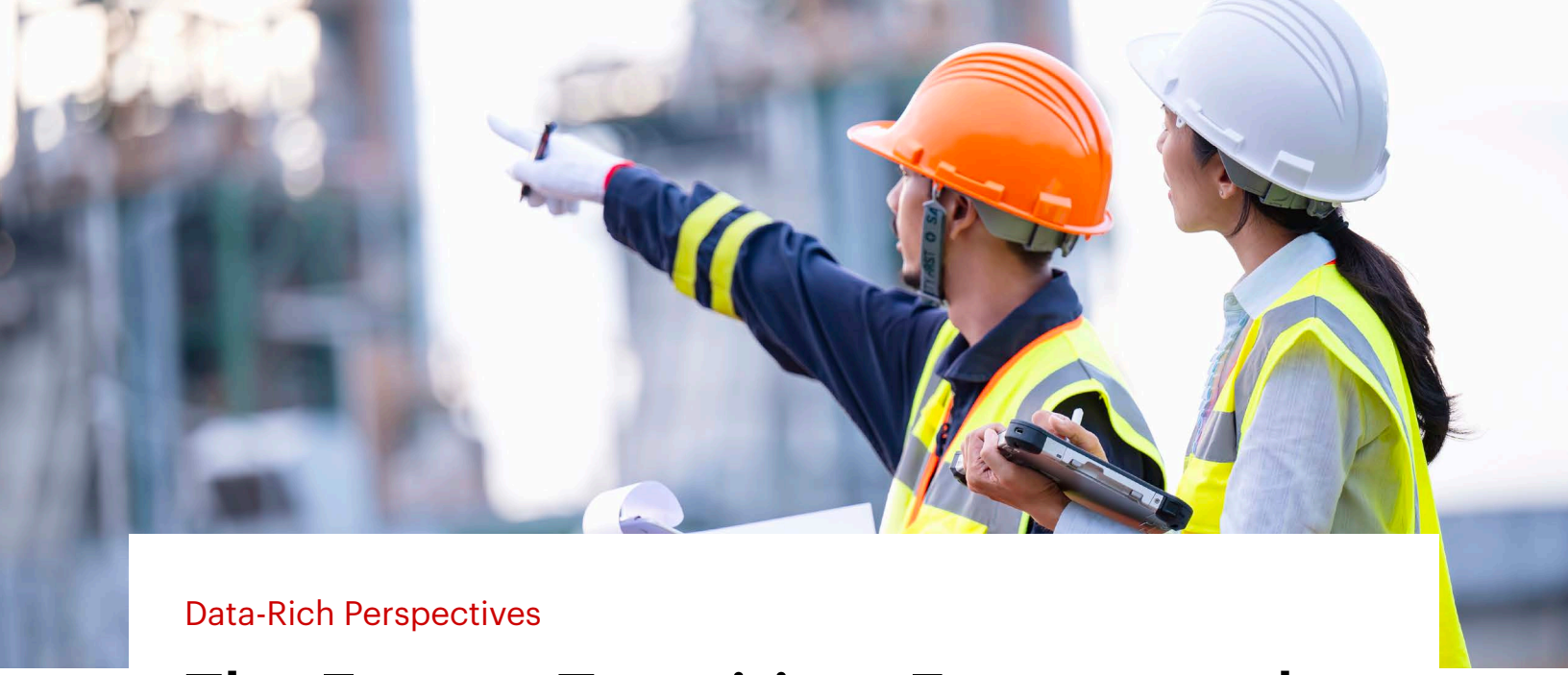


Notes: Warming figures in left-side emissions chart are relative to the preindustrial period and reflect projected warming level by 2100 in each scenario; bold lines in left-side emissions chart represent median estimate, and shaded regions reflect a range from the 25th to 75th percentile; emissions in right-side chart reflect global CO_2 emissions inclusive of land use change and exclude non-CO_2 emissions like methane
Sources: IPCC, Sixth Assessment Report; World Bank; Global Carbon Project; BP Statistical Review of World Energy 2022; Bain analysis

Adding these factors together, we arrive at the target scenario in the third panel: bending the emissions curve while still serving higher energy demand. Breaking the relationship between energy and emissions is at the heart of the dual challenge. The essence of it is achieving “low carbon” without compromising “reliable, affordable, and secure” as the energy supply expands.

Importantly, the journey will be different for every country. In low-income developing and emerging economies, the objective is to lift countries out of energy poverty and support industrialization in a low-carbon way, without erecting barriers to economic development (i.e., without following the historical trajectory of advanced economies). In advanced economies, it’s about reducing emissions while maintaining high living standards and economic growth. Companies that succeed will work in increasingly localized ways to support the energy and carbon journeys of different countries worldwide.

Solving the dual challenge will be enormously difficult due to its colossal scale and complexity and the importance to society of what we must replace or augment. The cost of failure in either direction is high: a rapidly warming planet and the consequential environmental risks, or stifled economic progress and lingering quality-of-life concerns for the billions of people who lack access to sufficient energy. But the outcome is not predestined, and it will depend on the actions we take to address the challenge.



Data-Rich Perspectives

The Energy Transition: Fragmented, Disorderly, and Ripe with Opportunity

Companies that capitalize on the transition's bottlenecks and scarcities will unlock both shareholder value and a smoother transition for the world.

By Michael Short, Jorge Leis, James Nixon, and Ann Siml

At a Glance

- Bottlenecks and scarcities will define the pace and depth of the energy transition in every market while also creating substantial opportunities.
- Locating and capturing returns on investment in low-carbon businesses will be a greater challenge than accessing capital.
- To succeed, companies will need to build new strategic and operational muscles and to view value chains differently.

In some aspects of the energy transition, we're seeing startling progress. There were record investments in the future energy system in 2022 (1%–2% of global GDP), including a net addition of more than 250 gigawatts of wind and solar capacity. New electric vehicle sales have doubled across Europe, the US, and China. Major clean energy stimulus policy—including the US Inflation Reduction Act—is pumping billions of dollars into the clean energy economy.

At the same time, geopolitical and economic forces have dampened progress in other areas. In the wake of Russia's gas supply cuts, various European countries fired up coal plants for electricity generation. India retreated from its thermal coal import targets due to the power crisis following last year's heat waves. Policymakers in some jurisdictions enacted fiscal measures and price interventions to reduce the impact of rising energy bills on consumers.

There's no clear consensus on what the transition's end point will look like or what pathway will take us there. For executives of energy and natural resource companies, the more pressing concern is navigating the global energy and carbon transition already taking place. Even if the world can't meet its ambitions for limiting warming to 1.5 degrees Celsius above preindustrial levels, the transition will prove massively disruptive to the energy sector.

There's no clear consensus on what the transition's end point will look like or what pathway will take us there. For executives of energy and natural resource companies, the more pressing concern is navigating the global energy and carbon transition already taking place.

This multi-decade period of transition is likely to be messy, involving more frequent shocks to key commodity markets and value chains. The world isn't investing in new energy systems fast enough to deliver them quickly, nor is it investing in traditional energy sources (which remain necessary during the transition) at the levels historically required to sustain them. In addition, rather than collaboratively managing a complex transition, the world is fragmenting economically and geopolitically.

Companies that lean into this era with enthusiasm, even if it requires a departure from the ways of the past, will be well positioned to both create tremendous value for their investors and unlock a smoother energy transition for the world.

Bottlenecks shape the pace and profits

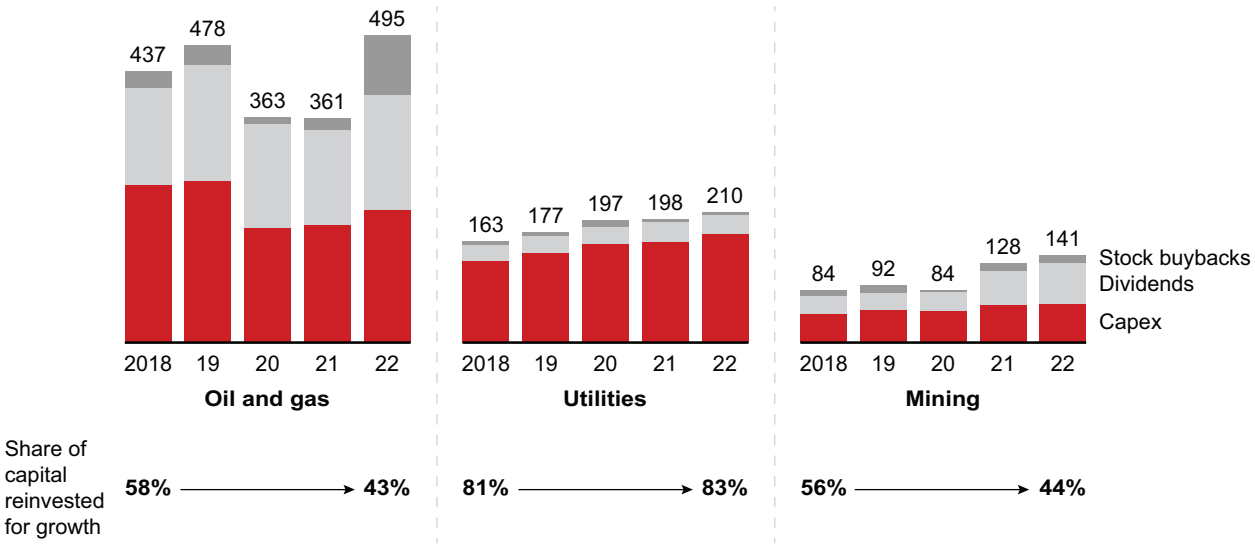
Executives are of course familiar with the laws of supply and demand, but viewing the energy transition through the lens of bottlenecks and their resulting scarcities can help companies spot business opportunities. Scarcity governs access to resources, infrastructure, commodity flows, and profit pools. When demand exceeds supply, it creates economic rents that induce investment to ease the scarcity—whether it's a global commodity or a piece of equipment in a local infrastructure network.

Bottlenecks and scarcities will define the pace and depth of the energy transition in every market and sector. It's helpful to think of them in three categories: paying, building, and operating.

Bottleneck 1: Who pays? Energy transition progress is often measured by the gap between capital required and committed. Although the world's committed investments fall far short of the annual capital required to reach net zero by 2050, capital itself isn't necessarily the constraining factor. It's available in most energy and natural resource industries, but instead of being reinvested for growth, an increasing percentage is being returned to shareholders.

This is the case in the oil and gas and mining industries, for example. Meanwhile, in utilities, the share of capital being reinvested for growth is steady and capital expenditures are increasing *(see Figure 1)*,

Figure 1: Some energy sectors are returning a growing share of capital to shareholders, while others are maintaining the share of capex



Notes: Includes 75 of the top energy and natural resource firms by market capitalization in each sector; capex excludes M&A
Sources: S&P Capital IQ (as of April 2023); Bain analysis

but it's not yet enough to modernize and expand the grid for the target levels of renewable energy and electrification.

Why is this? Global energy and natural resource executives rank the availability of capital among the bottom three barriers to scaling up low-carbon businesses, according to Bain's 2023 energy transition survey (see Chapter 1 of this report). Instead, return on investment and customer willingness to pay are top of mind.

Bottlenecks and scarcities will define the pace and depth of the energy transition in every market and sector. It's helpful to think of them in three categories: paying, building, and operating.

Without demand that's sufficiently profitable on a risk-adjusted basis, there's limited incentive to develop supply or the infrastructure required to make supply and demand meet. This makes economic returns a first-order scarcity, and locating and capturing them will be a primary challenge of the transition. One path is to anchor on end markets and consumers who are willing to pay the green premium associated with many new energy sources. Every new technology has these early adopters, but identifying and selling to them requires a different mindset for most companies.

Without enough customers willing to pay (or regulations driving them to do so, as is the case in Europe, where industrial consumers are subject to a carbon cap-and-trade program), the only other major source of funding would be governments (taxpayers). This could take the form of taxing alternatives, subsidies that alleviate the cost of production, or direct funding.

Encouraging examples exist across the globe. The US and EU have implemented policy measures to advance the transition, supported by significant government funds. These regions represent the lion's share of global government investments in clean energy. However, with steeply increasing interest rates and debt-to-GDP ratios in the US and EU, it will prove more difficult to pay for these initiatives. Economic returns may be even harder to find in the developing world, where country risk premiums, counterparty and currency risk, and lack of infrastructure can push required returns much higher than in OECD countries.

Policy can rearrange the rules of the economic game board quickly and dramatically. With geopolitics and the world economy generally fragmenting, it's safe to assume that the local/national policy landscape will be at least as important as global institutions. The US Inflation Reduction Act (whose

passage was a surprise in many circles) made green hydrogen production instantly cost competitive with gray hydrogen—and sparked a backlash in the EU.

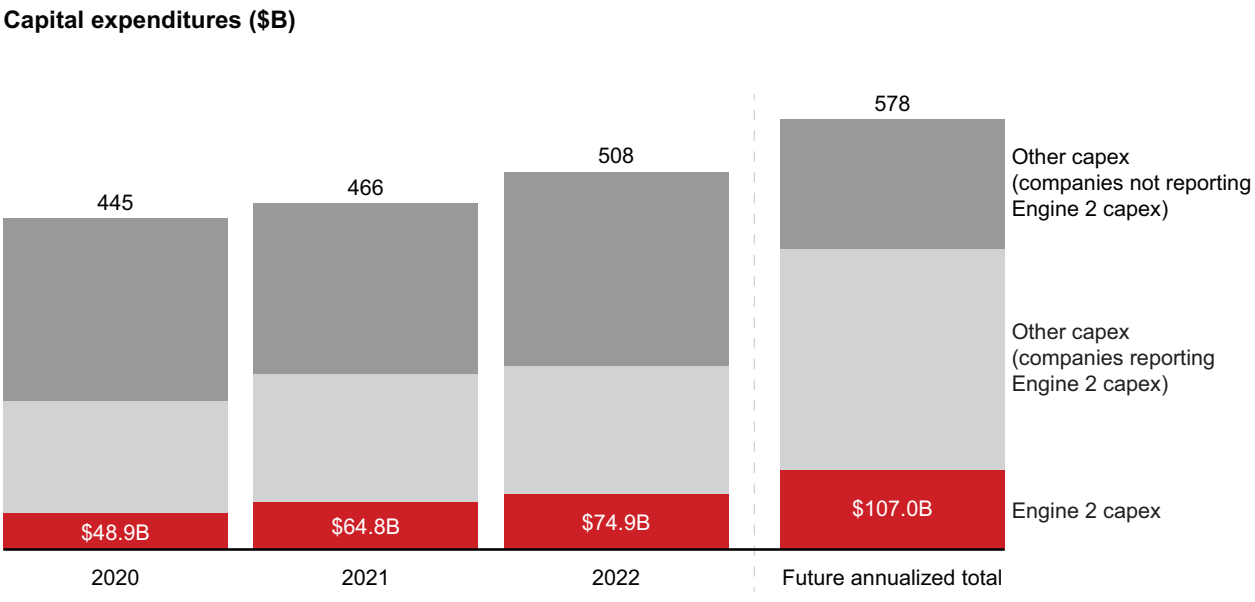
In many areas of the new energy ecosystem, markets will not only be regulated by policy but may indeed be created by government. For companies that typically shy away from stroke-of-pen risk, there are compelling reasons to be ready to shape and seize stroke-of-pen *opportunity*.

Bottleneck 2: Who builds? According to Bain research, 125 of the top energy and natural resource firms by market capitalization in each sector continue to modestly increase the capital allocated to low-carbon growth areas *(see Figure 2)*.

However, developing new energy systems and infrastructure at anything near the pace expected for the transition may push supply chain capacity beyond the breaking point, spurring transformation in some cases. Energy transition ambitions demand record-setting growth in many sectors.

Scarcity will shape and inhibit investment decisions as companies seek access to skilled people, manufacturing and processing capacity, and raw materials and other inputs. For example, the world isn't extracting enough metals and minerals critical to renewable energy technologies to meet net-zero targets. And the US would need to more than double its energy transmission capacity to

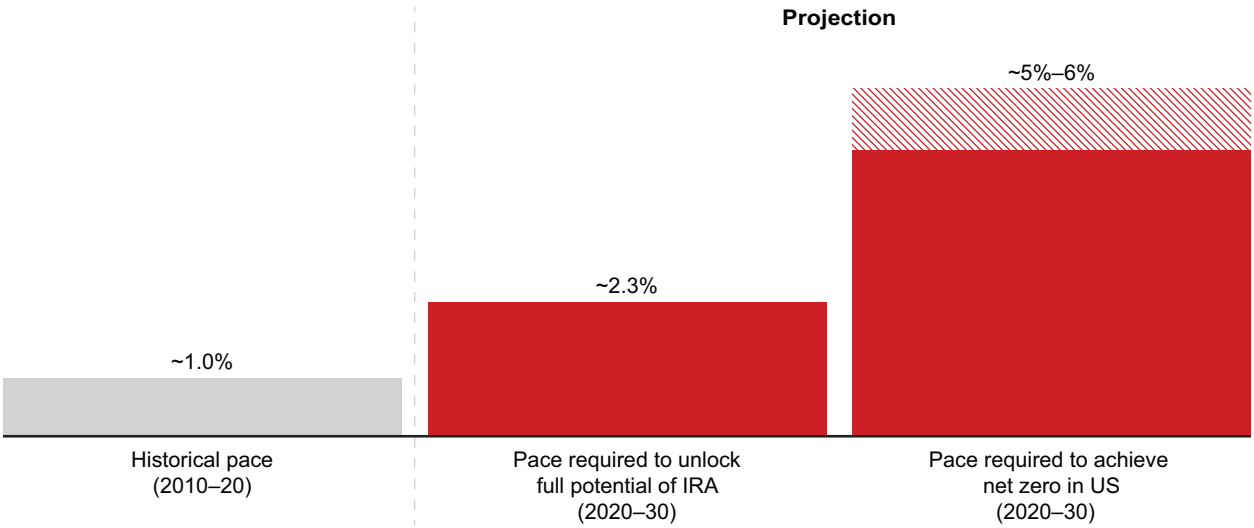
Figure 2: Energy and natural resource companies are increasing investments in new growth areas



Notes: Includes 125 of the top energy and natural resource firms by market capitalization in each sector; Engine 2 refers to new businesses outside a company's traditional core; future Engine 2 capex refers to annualized capex forecasts or commitments to Engine 2 between 2023 and 2030, with specific time horizon varying across companies; where future total capex projections weren't provided, the most recently reported total capex figures were used
Source: Bain Engine 2 database (as of May 2023)

Figure 3: US energy transmission capacity would need to more than double to reach the Inflation Reduction Act's full renewable power generation potential

US high-voltage transmission capacity growth per year



Note: Transmission capacity growth measured using gigawatt-miles
Sources: Princeton University, *Net-Zero America*; Princeton University, *Electricity Transmission Is Key to Unlock the Full Potential of the Inflation Reduction Act*; J.P. Morgan, *2022 Annual Energy Paper*; Bain analysis

take full advantage of the Inflation Reduction Act's potential impact on renewable power generation *(see Figure 3)*. Technology will improve and costs will decline with experience, but scarcity pricing can reverse those cost improvements for as long as it takes to relieve the bottleneck.

Just as supportive economics are uncertain for energy producers and suppliers, the rest of the value chain is also wary of making large investments based on predictions of new energy adoption. Forward-thinking companies will anticipate these bottlenecks and shortages, which will often occur several steps removed from the new energy commodity that gets the headlines. Depending on a firm's starting position, it can either seek to play defense (locking in supply certainty even if a bottleneck emerges) or offense (positioning itself around the potential bottleneck to capitalize on surging demand if and when it materializes). That's why General Motors invested $650 million in a lithium development project, Ford has made similar long-term purchase commitments, and Tesla is considering all forms of backward integration into key materials—an approach consistent with the early days of SpaceX.

Bottleneck 3: Who operates? Operational requirements are changing, probably faster than at any point in the sector's history. One clear example: As companies reduce their Scope 1 and 2 carbon

emissions, they'll need a growing supply of low-carbon power. The question is whether that can be reliably contracted in the context of utility market structures that also must evolve significantly. In some cases, the company may prefer to secure supply and generate that power itself.

Early examples show what happens when this challenge isn't addressed. Average power outage duration in the US due to major events more than doubled between 2016 and 2021. Energy markets in Europe were struggling to deliver enough reliable, low-cost power to the grid—low carbon or otherwise—in the second half of 2021, even before Russia's invasion of Ukraine. And Pakistan routinely experiences rolling blackouts even on normal weather days, driven in part by its inability to access a continuous supply of liquefied natural gas when gas was scarce, in spite of existing contracts.

Rather than waiting for the dust to settle while others set the operational norms of the future, leading companies will anticipate these bottlenecks and maneuver into positions of strength.

The steady-state requirements to both deploy and operate these newer systems at scale are only partially visible to us now. What can the industry do to ensure the supply of talent and spare parts needed to perform maintenance on wind turbines or solar farms, keep a smart grid operational, or drive the fleets of ships and trucks that will keep new energy commodities moving around the world? To the extent that new sources of energy are intermittent or reliant on different supply chains, how does the system as a whole achieve resilience and reliability? How will companies obtain feedstock to produce biofuels at the scale required to decarbonize air travel or long-haul trucking? Who will earn the right in the eyes of residential and industrial customers to optimize sources and uses of energy behind the meter, and with what technologies and combinations of assets?

Rather than waiting for the dust to settle while others set the operational norms of the future, leading companies will anticipate these bottlenecks and maneuver into positions of strength.

Succeeding in an era of bottlenecks and scarcities

For energy and natural resource executives, it's not enough to decide which parts of the energy ecosystem (old and new) to participate in at the headline level. The most effective companies will choose where to play and how to succeed in a way that capitalizes on the opportunities. Whatever course a company charts, new muscles will be required. Here are some of the most consequential.

- **Commercial capabilities.** Energy and natural resource companies are exploring how to unlock profitable customer segments via their go-to-market and commercial excellence capabilities. Early adopters with less price sensitivity may not always be a large customer segment, but finding and catering to them allows a company to participate profitably and maintain shareholder trust even as it stretches beyond its historical core businesses.

- **Proactive policy shaping.** Some natural resource companies (e.g., regulated utilities) are used to surviving and thriving in policy-driven markets. But for many, this is a new motion. Clear strategies and participation models linked to deliberate policy positions and toolkits can ensure companies are positioned to benefit as market rules evolve; indeed, they can help shape entirely new markets. Stakeholder coalitions will be critical to preserve license to operate, collectively influence the policy landscape, and create the conditions required for positive risk-adjusted returns.

- **Value chains and participation models.** As it becomes more essential to guard against or capitalize on bottlenecks, companies are adopting a less adversarial approach to the supply chain. See, for example, our brief "Energy Transition: Delivering Capital Projects On Time and On Budget," which illustrates how leading project owners are exploring more collaborative, mutually beneficial relationships with contractors. They're also increasingly willing to try new participation models, vertical integration, creative partnerships, and system-wide thinking.

- **Capital planning and resilience.** Companies used to deploying long-cycle capital are beginning to reconsider investment criteria when they want to participate both in markets that are high risk/high return (such as resource extraction) and in those with lower risk/lower return (such as policy-driven markets). They're also contemplating a wider variety of risks, ranging from physical climate resilience to stranded assets. (For more, read the Bain Brief "Managing Stranded Costs on the Long Road to Net Zero" and Chapter 5 of this report.) Finally, uncertain futures call for portfolios of bets and low-cost options, where not every investment is expected to pan out.

The road ahead will be neither straight nor smooth. What's clear is the need to emphasize different capabilities, change worldviews, and evolve participation models.

The energy transition is well underway. But the unwelcome news for anyone exhausted by the vicissitudes of recent years is that we're closer to the beginning than the end. The road ahead will be neither straight nor smooth. What's clear is the need to emphasize different capabilities, change

worldviews, and evolve participation models. It won't be enough to triple down on one step of the value chain and trust global competitive markets to take care of the rest. Leading companies will expand the aperture to track the whole system, taking deliberate positions based on clear beliefs about where sustained, defensible opportunity will be created.

A herd mentality won't help spot the opportunities created by disruption. Those who can anticipate the scarcities and develop a tailored plan to attack them will create meaningful shareholder value while also doing their part to grease the sticky wheels of the energy transition.

Full-Potential Agenda

Full-Potential Agenda

Willing but Not Able? The Energy Transition Has a Scaling Problem

Emerging leaders are identifying tailored solutions for scaling up tomorrow's energy systems.

By Brian Murphy, Felipe Gattass, Katherine Dixon, Emily Emmett, and Nir Feinstein

At a Glance

- A number of practical barriers stand in the way of rapidly building the physical infrastructure that the energy transition requires.
- Overcoming them will be crucial, but many energy and natural resource executives are struggling to identify the solutions best suited to their companies' needs.
- Leading companies are applying tailored approaches that focus on solving scaling challenges differently in four areas: development, integration, venturing, and invention.

Achieving anything close to net-zero emissions by 2050 represents a civilization-wide transformation of the energy system and a generational opportunity for many energy and natural resource companies. It will require millions of new workers to change over tens of millions of pieces of machinery and equipment across both the energy and raw materials systems, and to develop hundreds of mines and supply chains for raw materials. It will also require access to millions of acres of land for renewables; energy transmission, distribution, and storage; and other necessities. Existing low-carbon technologies will need to be deployed much faster. Future technologies will need to move rapidly along the development and deployment curve.

Achieving anything close to net-zero emissions by 2050 represents a civilization-wide transformation of the energy system and a generational opportunity for many energy and natural resource companies.

In short, all elements of the new, low-carbon energy system and many continuing elements of today's energy system will need to scale up—and fast.

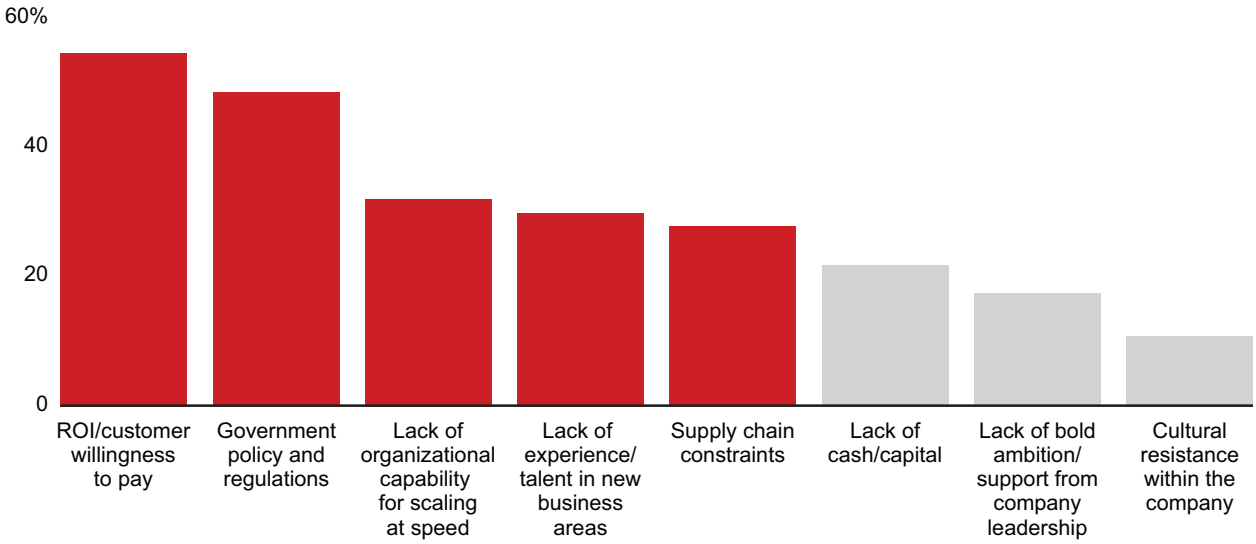
Energy and natural resource executives stand ready to get to work, but they face a number of barriers to scaling their efforts, our annual survey of 600-plus industry leaders found. Many elements are involved in scaling up new energy solutions, including making the math work and ensuring the new systems are resilient in a changing climate. But once those elements are in place, there's still the more practical challenge of getting projects done.

Our 2023 survey found executives aren't as concerned about their companies' internal will to scale up low-carbon businesses; relatively few see cultural resistance or lack of leadership support and ambition as significant roadblocks. Executives are more worried about whether they'll be able to scale up low-carbon businesses, as they face barriers related to customers, regulators, supply chains, and internal capabilities and experience *(see Figure 1)*.

The specific barriers to scaling—and their solutions—are unique to each company, technology type, and project. Scaling a mature renewable energy solution like onshore wind will be different from scaling an early-stage one like second-generation biofuels. Scaling demand, such as for green hydrogen offtake, will be different from scaling supply (e.g., electrolyzer manufacturing capacity). Scaling something that is closer to the existing core business—such as reservoir carbon capture, utilization, and storage (CCUS) for an oil and gas company—is different from scaling something distant from the core business, such as an alternative-carbon-products business for an oil and gas firm. Many executives face several of these dilemmas within the same corporate P&L.

Figure 1: Many companies appear willing to scale up low-carbon businesses, but it's unclear whether they'll be able to do so

Share of executives who consider each factor to be a very significant roadblock to scaling their low-carbon growth businesses



Source: Bain ENR Transition Survey 2023 (n=608)

On one hand, the fact that each solution will vary is formidable, and, from a climate change perspective, frightening. On the other hand, breaking it down can help identify the most effective, tailored strategy. The emerging leaders are focusing on four common scaling challenges:

- **Development**—stage-gate-like maturation of a material piece of infrastructure or a supply chain
- **Integration**—piecing together disparate, existing building blocks across technology, capabilities, value chains, or market participants
- **Venturing**—scaling up early-stage growth opportunities outside the core business
- **Invention**—innovating and generating new ideas

Part of the art of scaling is to ensure that the right solutions are applied to the right challenge. For example, a traditional scaling approach that works for development projects could kill a venturing opportunity. Similarly, Agile innovation isn't the answer to long-cycle infrastructure project development. This may sound intuitive, but in the rush to solve the scaling problem, many companies take the wrong path and stall progress. And because any given company will have a portfolio of energy transition priorities, it may need to execute across all four scaling challenges simultaneously. That becomes a real test of business capabilities.

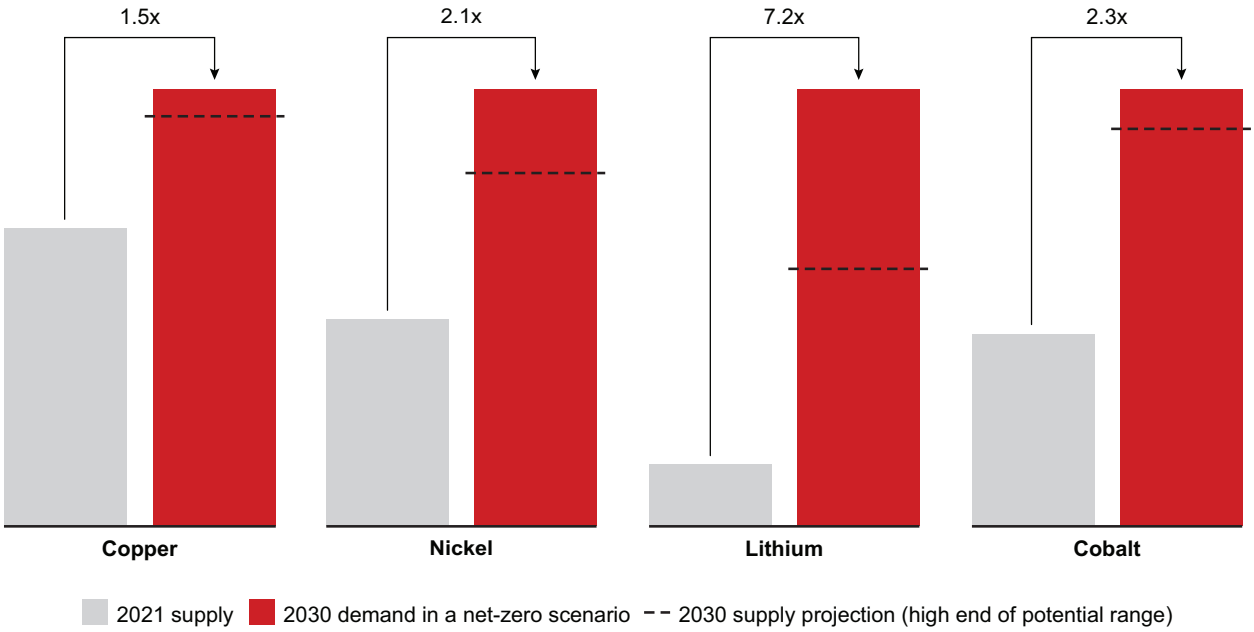
Scaling challenge No. 1: Unlocking development

Parts of the energy and natural resource system that already exist at scale, with mature technologies, will need to ramp up significantly to meet growing demand. And the *way* in which they must ramp up is already familiar to the industry: development projects. However, the energy transition is putting fresh pressure on certain bottlenecks, such as developing critical minerals supply and processing capacity; expanding the rollout of mature renewable technologies for energy generation, transmission, and distribution; and expanding gas supply to either avoid coal in a developing economy or to meet growing demand for renewables and industrial feed in a developed economy.

Technological innovation remains important to scaling up development projects, but the key is reducing development time, both to reach the market and then to expand. Consider the daunting speed and scale of metals and minerals supply growth required by 2030 to achieve net-zero goals: Nickel and cobalt production need to double, while lithium must increase sevenfold. Bain's upper-range supply forecasts anticipate significant shortfalls *(see Figure 2)*.

Many large capital projects, such as mines, processing plants, offshore wind projects, and power transmission and distribution infrastructure, require over 10 years to come to fruition. Now, as the energy transition demands a different pace and scale, that project lead time is running into bottlenecks in two critical areas: stakeholder alignment and workforce capacity.

Figure 2: Projected metal and mineral supplies in 2030 fall well short of meeting demand in a net-zero scenario



Sources: IEA, *Energy Technology Perspectives 2023*; S&P Capital IQ Pro; Bain analysis

Getting stakeholders on the same page can significantly shorten time to market. Permitting in particular is often a time-consuming step, usually due to a combination of process inefficiencies, increasingly complex trade-offs, and stakeholder engagement across climate objectives, environmental issues such as local biodiversity impact, and community considerations.

In some European countries, renewable projects' permitting process can take up to 10 years, despite the EU's legal maximum of 2 years for new projects. In response, the EU earlier this year mandated that member states designate areas in which they will significantly reduce wait times for renewable projects.

A deep, local understanding of the policy and community environment can ease alignment and cut development time by years. While there are costs associated with this level of stakeholder engagement, the benefits of shorter permitting time are quantifiable, often meaning these investments pay off rapidly.

Workforce capacity is also a rising barrier to resource and infrastructure development. Consider the speed at which power grids require buildouts. Historical transmission capacity in the US has grown about 1% per year for the past decade. However, to achieve the full potential of the US Inflation Reduction Act (IRA), that figure must double, and to stay on track for the end-of-century warming target of 1.5 degrees Celsius, annual transmission capacity growth will have to increase to between 5% and 6%. This buildout will require 80,000 new electricians annually between now and 2031, according to some estimates. Similarly, France is struggling to find enough nuclear specialists to achieve its ambition of getting six new nuclear reactors up and running by 2035, a cornerstone of the country's net-zero plans.

No single company can address workforce capacity on its own. It requires collaboration across engineering, procurement, and construction firms; project owners; governments; universities; and trade groups.

No single company can address workforce capacity on its own. It requires collaboration across engineering, procurement, and construction firms; project owners; governments; universities; and trade groups. At the individual company level, leading firms deeply understand future talent needs and seek creative solutions to bring that talent into the fold.

While those external factors generally present the most acute challenges for companies, some are speeding up development projects through their own ways of working. Forward-looking energy companies with traditional approaches to major capital projects or mergers and acquisitions are starting to take a more dynamic and flexible approach to decision making, enabling faster launches. (Read more in the Bain Brief "Energy Transition: Delivering Capital Projects On Time and On Budget.")

Scaling challenge No. 2: Unlocking integration

Overcoming some energy transition barriers requires new system capacity but not necessarily new ideas. Scaling success in this category is akin to a physical form of IT systems integration. Examples include digital tools that help optimize energy grid storage and dispatch, or better connecting supply and demand in industrial clusters. This is happening at a macro level, such as initiatives integrating consortia and supply chains to provide hydrogen to multi-industry business clusters, as well as at a smaller scale, such as utility companies building energy-as-a-service platforms for industrial and other enterprise customers.

Policymakers and governments are uniquely positioned to act as local catalysts for expanding capacity in burgeoning supply chains. That could be via direct funding, such as the approximately $7 billion commitment from the US Regional Clean Hydrogen Hubs program to establish 6 to 10 domestic hydrogen hubs, or the EU's €1 billion investment in the region's hydrogen industry. Meanwhile, some governments are taking a leadership role connecting companies, researchers, local authorities, and citizens to identify and carry out solutions. The Mission Innovation Hydrogen Valley Platform cofounded by the EU is one example.

However, finding the talent to lead integration solutions and stakeholders is often difficult. Rather than expertise in functional disciplines—from digital capabilities, electrical system design, and joint venture negotiations to niches like customers' offtake and usage patterns or electrolyzer manufacturing—project leads who have significant "techno-commercial" hybrid skills to integrate all of these areas, or who are great at nurturing partnerships, will be more likely to succeed. But people with this skill set are few and far between. Energy and natural resource companies may have to recruit from engineering firms, technology companies, government, or other corners of the industry.

It doesn't help that many parts of the energy and natural resource industry are struggling to find and keep talent anyway. Nearly 40% of executives in our 2023 industry survey said they're having trouble finding digital and IT talent, about a third report difficulty finding the engineers they need, and a quarter are struggling to find frontline labor. This is forcing traditional energy companies to rethink how they hire, manage, and retain talented people. A large international energy company has worked to widen its talent pipeline and increase diversity by taking a skills-first approach. It reevaluated job descriptions to remove requirements that weren't actually critical—for example, considering skills developed in other industries, recruiting at more schools, and considering a wider set of degree majors.

Scaling challenge No. 3: Unlocking venturing

A crucial piece of the energy transition will be scaling up promising subsectors of the energy system that are early stage but growing fast: Think green hydrogen use cases, second-generation biofuels, energy storage, CCUS, and broad energy-as-a service platforms. These subsectors will potentially achieve scale in the late 2020s or 2030s. They typically have a mix of technological, economic, policy, and commercial uncertainty reflective of their early stage. This next phase of scaling through the mid-2020s will likely determine the role that some of these solutions will have in the future energy mix. Success as an early scaler may make or break competitive advantage for the 2030s and beyond.

A crucial piece of the energy transition will be scaling up promising subsectors of the energy system that are early stage but growing fast: Think green hydrogen use cases, second-generation biofuels, energy storage, CCUS, and broad energy-as-a service platforms.

The playbook for growing a start-up applies here. The pace, test-and-learn cycles with customers, and partnerships all take on an entrepreneurial flavor. This scaling challenge is therefore more acute for incumbent participants in the energy system, whose honed growth muscles are different from what's required by the competitive dynamics of these emergent profit pools.

Once again, regulatory incentives can catalyze scaling in some of these markets. Biofuels mandates across the globe are paving the way for market growth. Meanwhile, in the US, the IRA's tax credits have triggered investment growth in green hydrogen production by making it instantly cost competitive with gray, and a Department of Energy loan guarantee program supported the commissioning of the world's largest hydrogen storage facility.

Nevertheless, the scaling barriers for venturing tend to be more internal than the other challenges. Commercial excellence will be essential and may require developing new muscles. Finding pockets of customers willing to form partnerships is critical to ensure demand offtake and a strong market position. Furthermore, leading companies' sales teams are adept at understanding customer needs, creating risk-sharing arrangements across multiple parties, product testing and learning, collaborative solution-engineering, and account management.

Attracting outside talent is often a key to success. Leading companies don't hesitate to rethink their recruitment strategy and value proposition for new hires. Ways of working may also need to change. Engine 2 businesses often rely on a strong operating model that allows for fast testing and learning cycles and a bias toward partnerships.

Scaling challenge No. 4: Unlocking invention

Some energy transition solutions are so early in development they'll still be novel and fledgling in the 2030s, and they may never come to fruition. This includes technologies at various stages of R&D or early commercial testing, such as direct air capture, fusion, and concentrated thermal storage. Call them "known unknowns." Other technologies are so raw and uncertain they're basically "unknown unknowns" at this stage.

Some energy transition solutions are so early in development they'll still be novel and fledgling in the 2030s, and they may never come to fruition. This includes technologies at various stages of R&D or early commercial testing, such as direct air capture, fusion, and concentrated thermal storage.

The work of scaling up these innovations is best tackled in the world of R&D, labs, and very-early-stage start-ups. Governments play an important role here, but so do incumbent energy and natural resource companies. According to Bain research, 125 of the top ENR companies by market capitalization in each sector spent at least $25 billion on R&D in 2022, more than half of the amount governments worldwide invested in energy technology R&D that year.

Asking the right questions

In the short term, companies that wish to lead the energy transition must lead in scaling up the required infrastructure and solutions. As executives develop their scaling strategy, a few simple questions can help them bring the right solution to the right problem:

- What scaling challenges apply to our company's energy transition opportunities?
- Given that, what are our true bottlenecks, and what will it take to unlock them? What's that worth to us?
- Will our current capabilities suffice to overcome our scaling challenges, or do we need to build new ones or form partnerships to fill gaps?
- What role could policy play in catalyzing our scaling, and what role can we play in catalyzing policy?

Full-Potential Agenda

Four Imperatives for Building Resilience in Energy and Natural Resources

The traditional focus on near-term risks leaves companies vulnerable to long-term challenges.

By David Knipe, Eric Beranger-Fenouillet, Aadarsh Baijal, Ethan Phillips, and Martha Eggenberger

At a Glance

- Traditional approaches to resilience focus on near-term risks, exposing companies to the threats of long-term challenges.
- These blind spots can leave executives overconfident about their companies' resilience, when most have yet to be tested.
- Leaders take a broad approach that includes strategic, operational, and supply chain resilience, in addition to managing the environmental risks to physical assets.

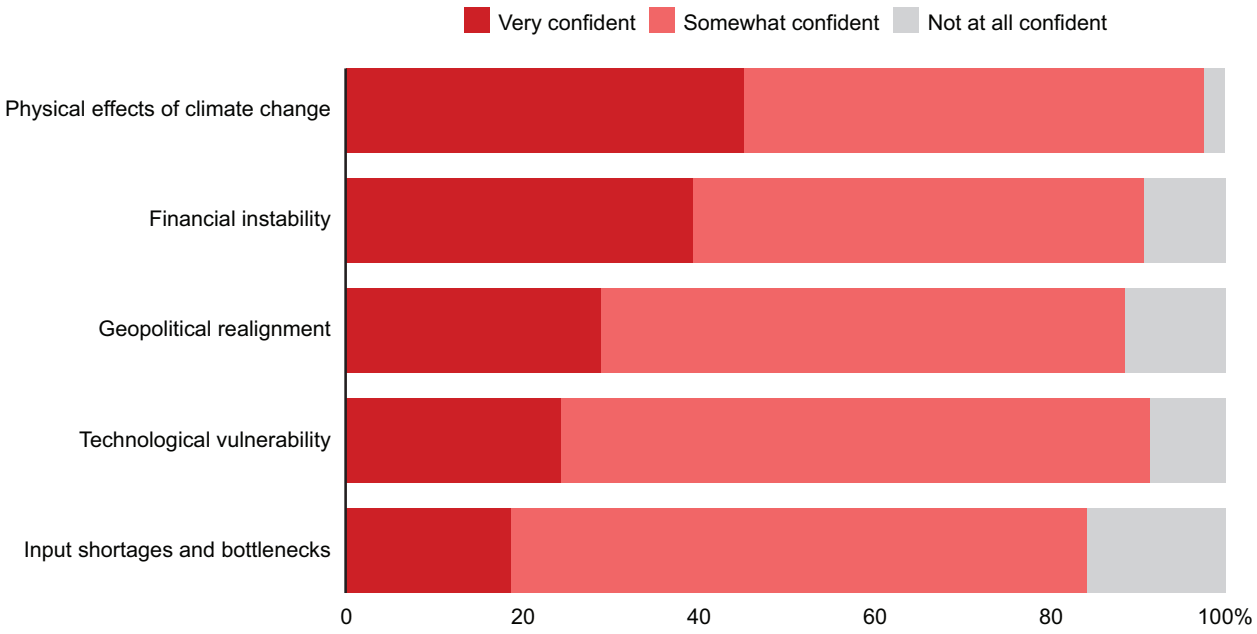
We are living through one of the most volatile and uncertain periods the world has seen for some time. War continues into a second year in Ukraine while nations continue to recover from the Covid pandemic. At the same time, the effects of climate change are materializing stronger and more often than before, as the world inches toward net-zero carbon emissions.

The need for resilience has never been more urgent for boards and executive teams, and resilience is likely to be one of the most critical strategic differentiators of a company's success.

But traditional corporate approaches to resilience don't rise to today's challenges. They focus too much on near-term risks, without fully recognizing the potential impacts up and down the value chain, well beyond individual company boundaries. They usually make very limited use of advanced predictive tools, which could help identify some of those risks. And they fail to connect risks to the organization's long-term strategic goals and economic model.

These narrow approaches can leave blind spots and create a false sense of security. Bain recently asked executives about their confidence in navigating five types of threats, spanning from the physical effects of climate change through to technological vulnerabilities, input shortages, and bottlenecks *(see Figure 1)*. Confidence across the board appears surprisingly high, especially as many of these threats continue to escalate.

Figure 1: Nearly all executives said they were very or somewhat confident in their ability to manage the physical effects of climate change



Source: Bain ENR Transition Survey 2023 (n=608)

These high numbers could reflect an overconfidence that's not entirely justified by the limited investments most firms are making in resilience. People often fail to accurately assess the magnitude and likelihood of rare events, such as the physical effects of climate change, since most have not experienced them firsthand.

Leading companies take a more comprehensive approach that includes strategic, operational, and supply chain resilience, in addition to managing the environmental risks to physical assets.

Strategic resilience

All strategy is formed amid some level of uncertainty, but the changes inherent in the energy transition multiply the difficulty. Uncertainty can handicap a firm in several ways. Overconfidence can lead to corporate myopia; under-confidence can leave firms in paralysis. Either scenario can stall action until it's too late to prevent a bad outcome.

"Existing assets are vulnerable to the instabilities ultimately caused by climate change and shortage of resources."

—Vice president, new energy company, Europe

It's rare that the losers in a transforming industry are really blindsided by change. More often, they fail to set a strategic direction that can adapt to shifting conditions. Leading firms start with a view of the future: What will customers need 30 years out? This approach can help companies set a long-term vision, free from the constraints of current practices and portfolios. Successful teams then plan for their long-term reference case, while continuously monitoring the environment and correcting course as necessary along the way.

Even among companies that invest in long-term scenario planning, few consider the "corner scenarios"—events that are possible but much less likely, like unexpected policy shocks or losing access to capital markets. Planners often shelve these scenarios because they don't want to invest time developing detailed plans for conditions that are unlikely to occur.

But ignoring high-risk scenarios is, increasingly, a short-sighted strategy. The tumult of recent years makes it clear that the energy and natural resource transition is likely to become more disorderly, even chaotic. Stress testing a company's capabilities has never been more essential, and it's one of the ways that planners can locate the extreme corners, in order to understand the implications and potential opportunities of low-probability, high-risk scenarios.

Operational resilience

Reducing Scope 1 and 2 emissions helps ensure long-term commercial viability in several ways. First, it positions a company to be closer to compliance as regulations or carbon taxes increase. Closely related, it helps preserve an asset's social license to operate, making it less susceptible to being targeted as a significant carbon emitter. It can also extend the working life span of the asset, given updates that renew operational capability. Reducing emissions signals all of these benefits to investors who are considering the long-term viability of businesses in a rapidly changing energy sector.

In addition to ensuring resilience for operations, companies also have to ensure that their decarbonization programs are resilient and can adapt to changing conditions. In this context, resilience means the ability to persevere not only through extreme weather events but also economic downturns, changes in technology, and other unpredictable barriers. Some companies are moving quickly to gain front-runner status while others are taking a wait-and-see approach, aiming to take advantage of more efficient technologies and economies of scale.

"The availability of a skilled workforce and overcoming key supply chain bottlenecks are critical to the transition."

—Vice president, utilities company, Europe

Supply chain resilience

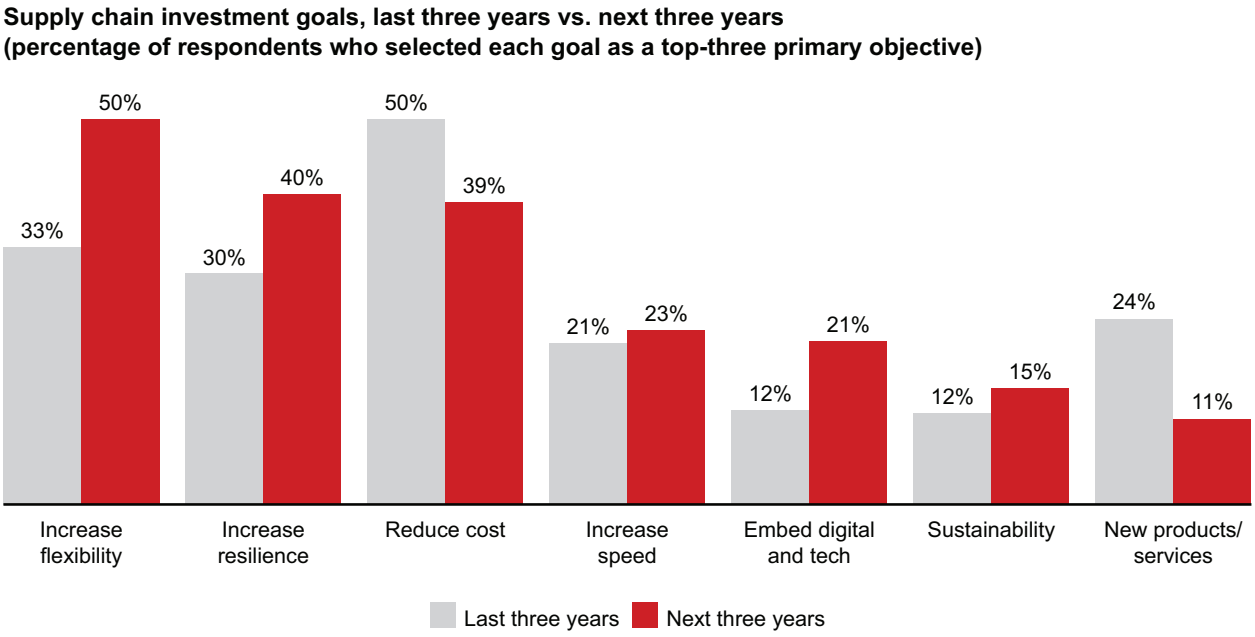
Once the purview of the COO and purchasing functions, supply chain resilience has risen to the highest levels of the corporate agenda over the past few years. The pandemic, a semiconductor shortage, and war in Ukraine are among the crises that have exposed vulnerable supply chains. Quality and price are still table stakes, but increasingly supply chain executives are investing to improve flexibility and resilience *(see Figure 2)*.

"A critical issue to the transition is that supply chains are highly concentrated, increasing vulnerability to disruptions."

—Vice president, power utility, North America

Supply chain resilience means different things across the sector, but in general it's the ability to proactively minimize risk, absorb inevitable shocks, and quickly recover from setbacks to lessen the impact on operations. Taking a holistic view of the entire chain can help companies identify the most important risks to the business and then assess the likelihood of each. Comparing strengths to competitors' can help companies find opportunities to differentiate while mitigating their impacts on energy markets and the environment.

Figure 2: Flexibility and resilience are becoming more important to supply chain executives



Source: Bain Supply Chain Industry Resilience Survey, September 2022 (n=275)

Physical resilience

Many companies are already experiencing the effects of climate change on their operations. For example, in 2022, Apple and Intel suffered a weeklong shutdown of some production facilities in Sichuan, China, where a drought stalled multiple hydropower plants. But many businesses underestimate the likelihood of physical climate risk events and their exposure to them, relying on a narrow set of risk-transfer tools (for example, insurance or financial hedges) rather than a broader set of strategic and operational levers for building resilience.

"It is imperative that climate change adaptation efforts be put to the fore. Risk management and business continuity practices should be in place to ensure stability of services."

—Senior manager, utilities company, Asia-Pacific

Power utility Southern California Edison, for example, has been working for more than a decade to manage the effects of climate change on its power grid and generation assets, which include more

frequent wildfires and droughts that jeopardize the viability of hydroelectric power. To address these risks, SCE embarked on a detailed assessment of climate risks to its assets, operations, and services across its 50,000-square-mile service area. The results helped SCE reprioritize capital investments for new infrastructure that can withstand more intense flooding and storms, extreme temperatures, and more severe wildfires. SCE says it invests about $5 billion each year to maintain and improve its grid, and that by the end of 2021 it had reduced wildfire risk by about 70% compared with pre-2018 expectations.

A more proactive approach to resilience starts with a systemic look across the entire value chain, using analytical tools to estimate risks today and in the future. Companies can then focus on practical actions to adapt to these risks and make decisions about which assets or facilities to protect and what strategic changes may be necessary to survive and thrive. The changes may include revising capital planning processes, restructuring or nearshoring the supply chain, or advocating for new policy solutions.

Full-Potential Agenda

The Energy Transition's Other Big Puzzle: Making the Math Work

Strong investment returns are within reach for companies that focus on the fundamentals and aren't afraid to get creative.

By Grant Dougans, Anders Bruhn, Dalton Maine, Valeria Sterpos, Francesco Cigala, and Shazrul Asari

At a Glance

- The energy transition would generate at least $55 billion in new earnings each year if the world approached the annual investment level required for net zero.
- Unlocking the trillions of capital dollars available remains difficult; many companies struggle to chart clear pathways to investment returns on their low-carbon projects.
- Leading companies are using policy, commercial capabilities, creative financing, cost discipline, and other strategies to make the math work for their low-carbon investments.

Delivering on the energy transition's ambitions comes down to economics: How can the world make the $4.6 trillion annual investment required for net zero pencil out?

As investors and other stakeholders form global coalitions such as the Glasgow Financial Alliance for Net Zero (GFANZ), there's no question that there are trillions of capital investment dollars worldwide looking for a home in low-carbon energy systems. Capital seeks returns. If low-carbon capital investments approached the annual $4.6 trillion that the International Energy Agency (IEA) estimates is required by 2030 to achieve net-zero carbon emissions by 2050, the energy transition would generate a new $55 billion earnings pool each year—a low-end estimate if one assumes an average 20% equity weighting for projects and a 6% return on that equity. That's the generational upside that so many companies are pursuing around the world as they work to scale up their new energy-related businesses.

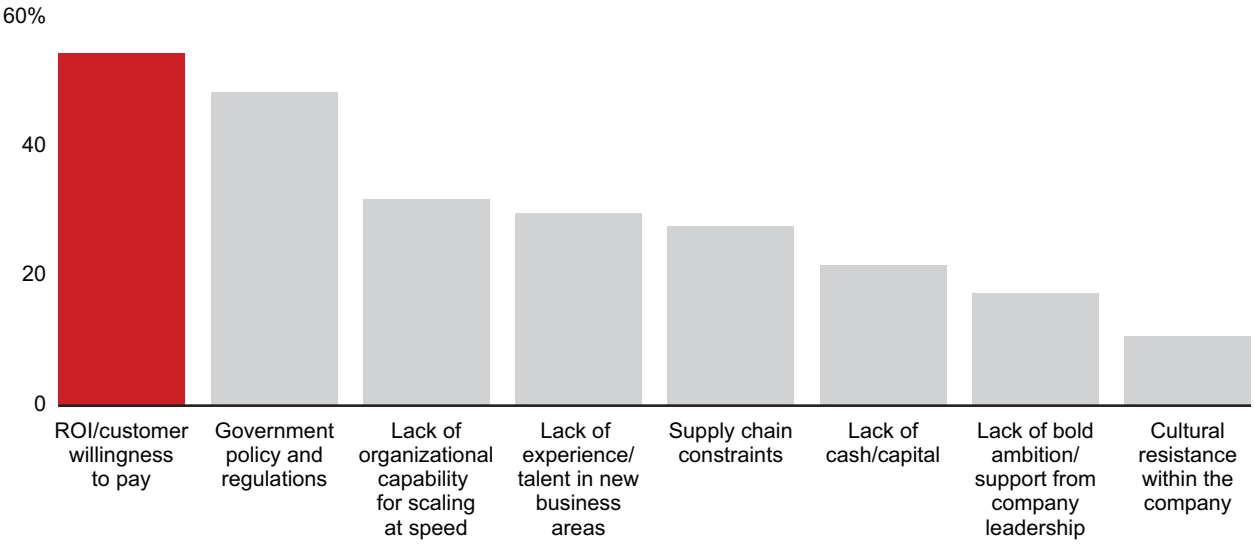
Despite the opportunity, less than $2 trillion per year is being deployed into clean energy worldwide across the private and public sectors, according to IEA data. In Bain's 2023 survey of more than 600 energy and natural resource (ENR) executives, respondents confirmed that they expect to allocate only about 25% of total capital to new low-carbon growth areas. This is largely unchanged from last year's survey and consistent with the capital allocation data sourced through Bain's analysis of 125 of the top energy and natural resource companies by market capitalization in each sector. What's more, according to that same data, almost half of the enormous cash windfall those companies received over the last two years was returned to shareholders rather than reinvested into new low-carbon projects.

Although the challenges are multifaceted and complex, ENR executives said in our 2023 survey that the most formidable constraint on scaling up low-carbon systems isn't access to capital or even supply chain challenges—it's securing sufficient returns on investment and customer willingness to pay higher prices to cover that capital, once deployed.

What's going on? Although the challenges are multifaceted and complex, ENR executives said in our 2023 survey that the most formidable constraint on scaling up low-carbon systems isn't access to capital or even supply chain challenges—it's securing sufficient returns on investment and customer willingness to pay higher prices to cover that capital, once deployed *(see Figure 1)*. Put another way, most companies have ample access to capital markets. It's customer revenue they're hunting in order to grow these businesses by an order of magnitude in coming years. Until that problem is solved, the $4.6 trillion global investment goal will remain out of reach.

Figure 1: Executives say the greatest obstacles to scaling low-carbon businesses are customers' unwillingness to pay higher prices and the difficulty of ensuring adequate returns on investment

Share of executives who consider each factor to be a very significant roadblock to scaling their low-carbon growth businesses



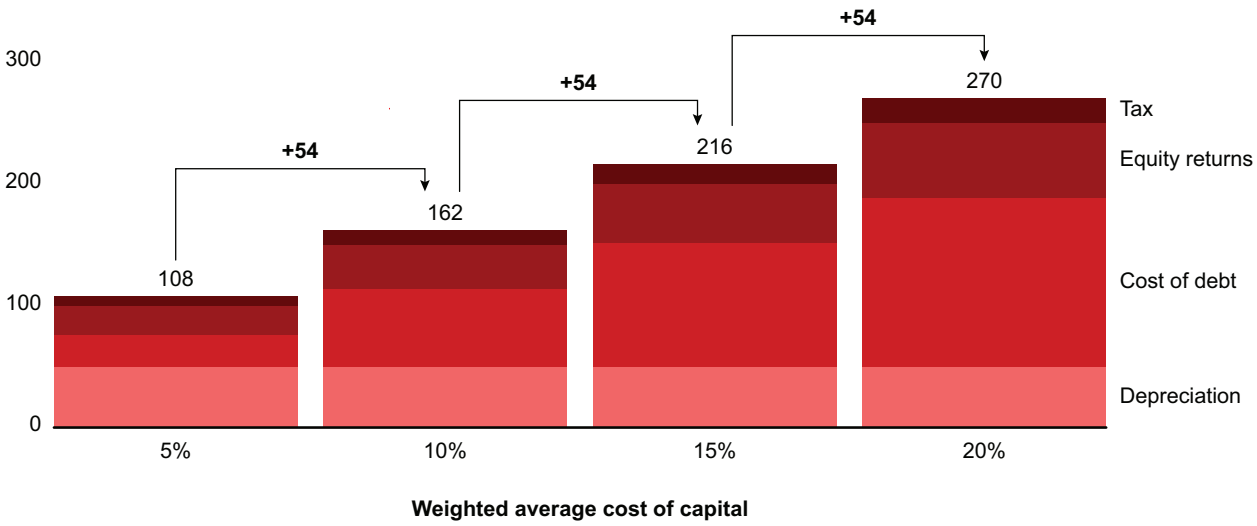
Source: Bain ENR Transition Survey 2023 (n=608)

Understanding the math of capital formation

The energy and natural resource industries are exceptionally capital intensive, as their executives and investors know all too well. For many low-carbon projects, the largest input cost is capital. Put simply, for any project to be built, capital providers must first ask and answer the questions, "who will pay? for how long?" and "is that enough?" Most capital allocators will be hesitant to invest before there are clear signals that demand will be there and returns will follow.

To give a clearer picture of the math surrounding capital formation, a simple rule of thumb is that for every $1 billion in capital invested in a low-carbon project, roughly $60 million in revenue must be collected to cover returns on equity, debt servicing costs, and taxes, assuming a low-risk asset with a 5% cost of capital. That asset must also be depreciated, increasing the revenue required to about $108 million per year, assuming a 20-year useful life. If risk increases, and with it cost of capital, the revenue that must be collected from customers grows further: For every 500 basis points increase in the cost of capital, the annual revenue requirement increases by almost $55 million *(see Figure 2)*. So, as central banks increase interest rates, the effective cost of any given low-carbon project increases as well. At a 10% average cost of capital, every $1 billion in capital deployed requires about

Figure 2: At least $108 million in annual revenue is required to form $1 billion in capital for a low-risk asset



Notes: Calculations assume 75/25 debt-equity project split with 600 basis points spread between debt and equity returns, a 20-year straight-line depreciation schedule, and a 25% average corporate tax rate; values are rounded
Source: Bain analysis

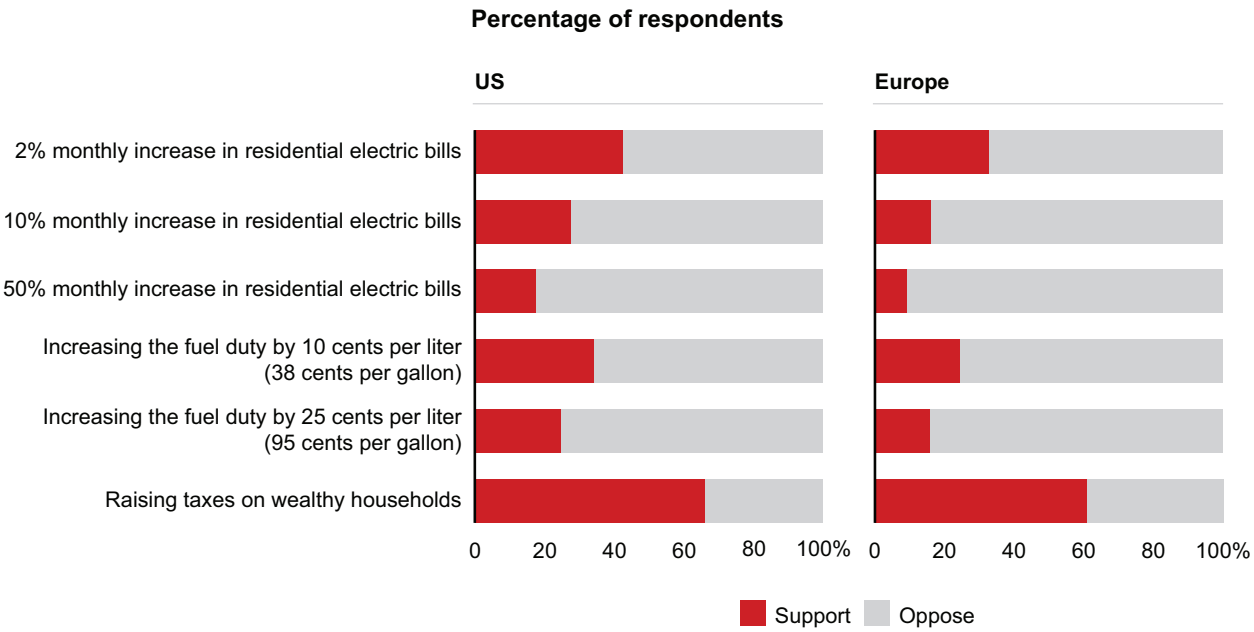
$160 million in revenue from customers each year. Furthermore, all of these costs come before operating and fuel expenses.

The trouble is that although consumers are concerned about climate change, data suggests that they may not be willing to pay higher bills to help combat it. Recent Bain surveys found that less than half of US and EU consumers are willing to pay even a small increase in their residential electric bill or fuel price to reduce emissions. Instead, they prefer raising taxes on wealthy households, suggesting that consumers believe government should intervene to bring down prices of new technologies *(see Figure 3)*.

For low-carbon projects serving business customers, such as sustainable aviation fuel (SAF) or chemicals, generating revenue requires finding a counterparty willing to pay a premium above the cost of legacy products and to provide longer-term revenue certainty. But as we discuss in our brief about a net-zero path for commercial aviation, the SAF premium can be significant.

Further barriers to capital formation and attractive returns can emerge based on an individual company's financial model and investor value proposition. Across energy and natural resource sectors, different companies have different investor value propositions, with different implied balances of

Figure 3: Most consumers aren't willing to pay higher prices for reducing greenhouse gas emissions



Sources: Bain US Consumer Pulse Survey, powered by Dynata, February 2023 (n=2,496); Bain EMEA Consumer Pulse Survey, powered by Dynata, Wave 7, February 2023 (n=12,585)

growth, risk, and return. Utilities investors generally seek low-risk, comparatively lower-return, asset deployment—a business model akin to a bank financing mortgages. By contrast, oil and gas investors understand that their sector's stocks are subject to large swings in returns as energy prices move. They're comfortable with that added risk because it's worth it to them to pursue higher returns (along with dividend payments), with potentially fast or lumpy payback periods based on commodity cycles. A utility investor would likely be uncomfortable if asked to finance a perfectly economic but risky (high-return) project, which is why US utilities have continued to shed non-regulated assets over the last decade. There would be similar challenges when asking an oil and gas investor to finance renewables projects with lower risk and lower return on capex than the existing base portfolio. Both types of projects may be perfectly viable, but different investors would value those risk/return profiles differently.

Tactically, a company's capital allocation and approvals procedures can also pose a challenge. Existing capital allocation processes may not be set up to effectively handle low-carbon projects' novel (from the standpoint of the legacy company) risk/return profiles. Something as simple as how a project's capital committee template is set up—and the differences in that template's underlying assumptions compared with a typical project—can make project approvals difficult to secure.

Practical solutions for executives

In our experience working with energy and natural resource companies worldwide, focusing on one or more of the strategies below can bolster the case for capital allocations and increase a project's return on investment.

Open new markets via policy. In many cases, pure market economics will be insufficient to create low-carbon revenue at the necessary scale or pace. Policies—including subsidies, taxes, and demand-side regulations requiring industries to use these new energies—will be required. At leading companies, management teams work with a broad range of stakeholders to use policy to carve out demand and associated revenues. Those that proactively shape policy and stakeholder landscapes will generate outsize returns and better manage risks, while helping secure corporate decarbonization commitments.

Policy's financial upside for energy companies can be startling. US agri-tech company Green Plains is simultaneously accelerating its decarbonization plans while generating shareholder returns. It's making optimal use of tax credits offered by the US Inflation Reduction Act (IRA) for carbon capture, utilization, and sequestration (CCUS) and carbon intensity reduction, as well as carbon credits offered by various North American governments. As a result, the company intends to more than halve the carbon intensity of its ethanol production platform while delivering a conservatively estimated annualized profit increase of $200 million to $280 million in EBITDA by 2027 over an estimated 1 billion gallons of ethanol production. This is one of many recent examples in the United States following the IRA's passage.

In our experience working with energy and natural resource companies worldwide, focusing on one or more of these strategies can bolster the case for capital allocations and increase a project's return on investment.

Neste, a biofuels producer based in Finland, has had an active presence in climate conversations during crucial policy-shaping moments. The company provides insights and analysis on, for example, emission reduction targets and renewable transportation fuels through public consultations and direct engagement with government officials and politicians. Neste also participates in industry associations that often have an instrumental role in informing government policy.

Build commercial muscles and mindsets. Leading companies also focus on developing pockets of customers who are willing to commit to their low-carbon product or service, often leveraging government incentives. This requires a deep customer-facing commercial capability that for many traditional energy and resource companies is a new muscle.

Examining potential customers' environmental activities and commitments can signal whether those customers might be willing to pay a green premium. One renewable energy company developing a clean hydrogen project started with a list of thousands of potential customers in its most attractive segments and narrowed it down to the 40 most likely customers. That allowed it to focus its sales efforts on targeted conversations that resulted in an offtake agreement that made the project economically viable.

In the biochemicals sector, Genomatica found an early partner in Lululemon to bring to market plant-based nylon that doesn't rely on petrochemicals. (For more examples of commercial excellence in the energy and natural resource transition, see our briefs "Unlocking Hydrogen Projects with a Customer-Centric Approach" and "Finding the Sustainable Advantage in Chemicals.")

Too often, companies assume all low-carbon projects should be financed by the corporate balance sheet, where investors may not appropriately value the risk/return profile of the proposed investment. Creative financing solutions can bridge the gap.

In another example, utilities are increasingly considering how to reframe bills to customers. For example, one utility is contemplating adding to each customer bill the effective gasoline savings associated with charging an electric vehicle (EV) at home. EV charging drives up electricity bills, but taking a "total energy wallet" view and talking with customers about the related gasoline savings can help consumers more willingly accept higher utility prices. This would be natural to many other industries, but for utilities, it represents a new mindset.

Keep costs down. A traditional approach to making the math work can also be crucial in low-carbon technologies and markets: Become a low-cost, scale leader. Businesses that grow large enough can receive advantaged access to key components at the lowest costs, thereby freeing up room for growth. For companies like utilities, which collect revenue from customers on an average charge basis, eliminating costs can help fund low-carbon investments.

Find creative financing solutions and reduce the cost of capital. All things being equal, given the amount of global capital chasing low-carbon opportunities, low-cost capital should be available for any feasible project. But companies often overlook creative balance sheet options to maximize returns for their shareholders and secure better infrastructure financing. Too often, companies assume all low-carbon projects should be financed by the corporate balance sheet, where investors may not appropriately value the risk/return profile of the proposed investment. Creative financing solutions can bridge the gap. In the offshore wind industry, for example, complex farm-down schemes are a well-established practice to lower the project's effective cost of capital and generate returns for the developer.

Leading companies seriously consider alternatives, such as taking a development fee and transferring the asset to another advantaged source of capital, lowering overall project costs. Taking a more active approach to pursuing partnerships with investors could also prove valuable. For example, oil and gas companies could coinvest with infrastructure funds on lower-risk, lower-return projects; with development banks for projects in emerging markets; or with private capital investors willing to take on riskier, longer-term projects.

Start with the sound strategy

There are many successful low-carbon businesses already increasing revenue and generating strong returns. Each year, renewables deployment is growing, with 2022 seeing a record net addition of more than 250 gigawatts of wind and solar capacity. That said, for every company achieving leading returns and growth, there is another struggling, as our survey results show.

There are many successful low-carbon businesses already increasing revenue and generating strong returns. Each year, renewables deployment is growing, with 2022 seeing a record net addition of more than 250 gigawatts of wind and solar capacity.

Developing a clear strategy that directly addresses the fundamentals of return generation in low-carbon markets is critical. With over $150 trillion in investor capital committed toward net-zero targets by GFANZ alone, being "just another provider of capital" isn't a recipe for attractive returns. Energy and natural resource companies have real competitive advantages against pure-play capital

providers, but they need the right capabilities to exploit those advantages and generate returns. Policy, commercial capabilities, creative financing, and cost discipline are a starting list of tools for supporting capital formation; there are others. While the global picture of the energy transition is complex, companies that are proactive, bold, and focused on the fundamentals of return generation will be able to overcome one of the most common challenges to scaling a low-carbon business. They'll also help move the world closer to its $4.6 trillion goal, one project at a time.

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