Global Energy and Natural Resources Report 2021: Navigating the Energy Transition

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Acknowledgments

This report was prepared by the leadership team of Bain & Company's Global Energy & Natural Resources practice, with special direction from Aaron Denman; Peter Parry, practice chairman; and Joe Scalise, global practice leader.

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Contents

Two out of Three Won't Do

Only by doing the hard things right can we make the big things possible.

Dear Colleague:

Industries in the energy and natural resources sector oil—and gas, utilities, chemicals, mining, and agriculture—face a unique and intense period of change as they navigate through the energy and resource transition.

None of the old imperatives have gone away: these companies still need to produce and deliver energy, materials, food, and services, efficiently, to their demanding customers. But that's only table stakes now. Climate change, shifting consumer preferences, demands for greater accountability, and unprecedented levels of business competition will all require new ways of working, technological breakthroughs, and leadership that can rapidly scale their deployment.

Over the past two years, our work with clients in these industries has changed, with three themes emerging.

- **Innovation.** The need to harness transformative technologies and practices to evolve their businesses will enable companies to continue to thrive while preserving the planet for future generations.
- **Impact.** More than ever before, the ability to work with customers and other stakeholders will be critical to ensure companies maintain the social license to operate complex businesses in the heart of our communities and fragile environments.
- **Economics.** Funding these transitions will require new levels of investor management and regulatory engagement. Companies will need to create extraordinary economic value to draw the capital and access the resources necessary to tackle these challenges.

We've written this report, the first in a planned annual series, to share emerging insights from this work and to support all of you as we collectively tackle the world's most important issues. We've taken a general manager's perspective to help you understand the issues and what you need to know to move ahead.

The report's first chapter unpacks the issues ENR companies are facing and explains why we believe it's essential for leaders to deliver on all three of these imperatives.

The next section highlights critical trends we see underpinning the energy and resource transition, emphasizing the connections across sectors and the speed of change. We look at these challenges through a future-back, customer-oriented view of the future—a perspective our clients find more

compelling than air-filled forecasts of massive profits or doomsday prognostications. It's also the approach we're taking with much of our client work, because it allows us to paint the target and work with organizations to find ways to reach it.

In the last section, we describe a set of strategic advantages that we see industry leaders building to shape the future. Managing through the transitions will require a fundamentally different approach to strategy, the operational model, and implementation priorities. Much of our work with clients focuses on building new capabilities, including operational decarbonization, second engines of growth, more efficient capital projects, scale digital and automation, and transformed supply chains, all with the aim of becoming a strategic differentiator. At the same time, the traditional core businesses must continue to generate revenues to fund the transitions, as they become more sustainable, too.

The energy and resource transition is likely to be a top priority for many of us for the rest of our careers. ENR leaders will drive the next wave of transformative innovation, evolve the social compact with customers and communities, and generate the capital required to create a more sustainable future. We at Bain look forward to continuing the discussion with our friends across the interconnected energy and natural resources industries.

Joe Scalise
Partner at Bain

Harnessing the Energy and Resource Transition

Energy and natural resources companies are uniquely qualified to address the challenges of the world's most important issues.

By Aaron Denman, Peter Parry, and Joe Scalise

At a Glance

- Over the past century, companies in the energy and natural resources sectors have helped lift billions out of poverty and made the modern consumer economy possible.
- Even so, many investors are betting against them in the energy transition, counting on insurgent companies with fewer legacy challenges to bring about change.
- But these incumbents have the capabilities to drive the energy transition at scale.
- To become important contributors to the essential changes, these companies need to get three things right: innovation, impact, and economics.

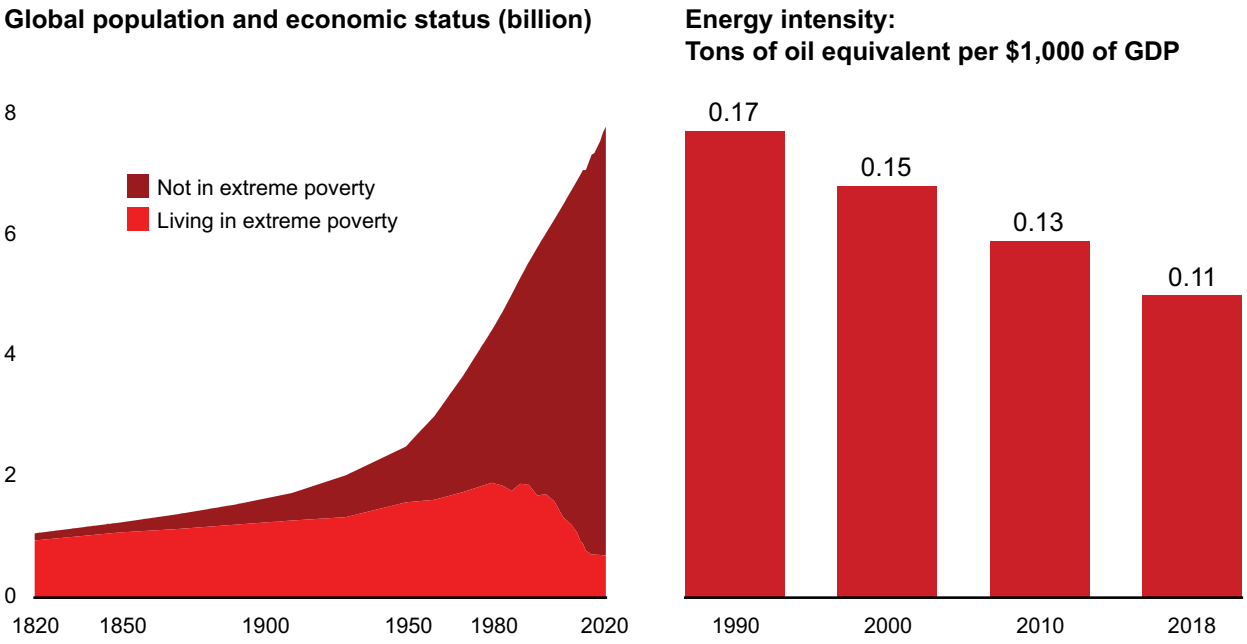
The next five years are going to be critical for the industries that supply energy and natural resources to the world's economies. In that short span, while they keep their current businesses running, most will begin reinventing themselves as businesses that also move the world closer to a lower-carbon, sustainable future.

Some investors are betting against them, shifting money from these incumbents to new companies that have less baggage and appear to be more innovative and more capable of solving the world's most important issues.

But it would be a mistake to count the incumbents out. These industries have already helped drive monumental shifts over the past century, delivering reliable and affordable energy that powers the world's markets, supplying raw materials that make the consumer economy possible, and ensuring a steady food supply that feeds billions *(see Figure 1)*. Even so, many energy and natural resources (ENR) companies that transformed the world are caught on the wrong side of a story line, legacy players in a sector that's ripe for disruption. The question being asked in boardrooms is: How do we fix that?

One way is to change our thinking about the role of energy and natural resources companies in this transition. The industries under the most pressure to change are the same ones that have the

Figure 1: The global population has grown to nearly 8 billion, while living standards have improved dramatically and energy intensity has decreased



Sources: Our World in Data; Population Reference Bureau; World Data Lab; Bain & Company; International Energy Agency

experience and organizations necessary to transform the world's use of energy and resources. Their achievements underscore their unique capabilities and also serve as the foundation for their next phase of growth.

It helps that the opportunities tied to the transition are compelling. Trillions of investment dollars are up for grabs, as the world rebuilds the infrastructure for a more sustainable and lower-carbon economy—renewable energy generation and greater electric grid capacity; industry and transportation that run more on electricity and hydrogen and less on fossil fuels; a circular path for consumer plastics that are more recyclable or more biodegradable; and an agriculture system that leaves a lighter footprint.

The adversarial stance we've grown accustomed to between many stakeholders (investors, customers, community members) and these companies has accomplished what it needed to: defining the necessary changes and spurring governments and industries into action.

The adversarial stance we've grown accustomed to between many stakeholders (investors, customers, community members) and these companies has accomplished what it needed to: defining the necessary changes and spurring governments and industries into action. The Covid-19 pandemic introduced another element to the discussion: the determination to build back better. Now is the time to work collaboratively, develop partnerships, and address the immense challenges inherent in the energy and resource transition.

Under scrutiny and squeezed for capital

ENR firms face two related challenges. One is that greater scrutiny from the public over sustainability and greenhouse gas (GHG) emissions is making it harder to obtain capital for expansion. The second is that capital is flowing to their insurgent competitors, which are disrupting these industries and beginning to take market share.

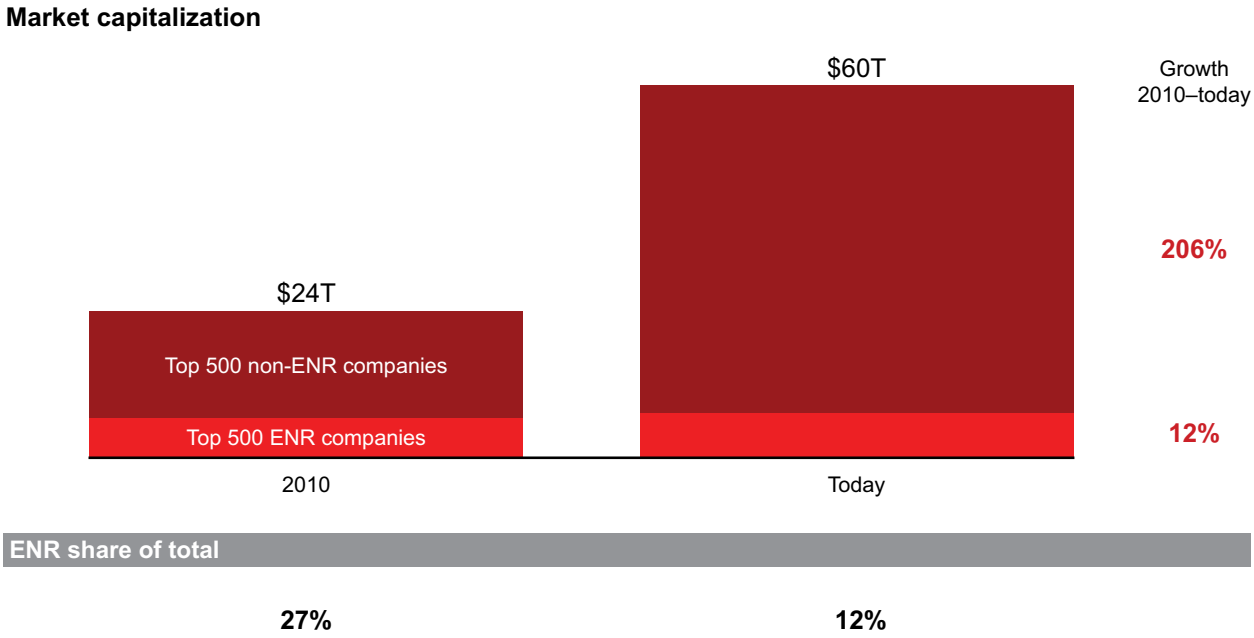
Attention to the damage from ENR industries—primarily carbon and other GHG emissions—poses an existential threat to existing business models, one that's more serious than in previous cycles of scrutiny. Weather events and wildfires are occurring more often and with greater intensity, and that's made climate change appear more imminent to people who once saw it as a far-off threat. Many energy and natural resources firms have found ways to reduce their environmental impact

over the past few decades, as in mining, where newer techniques have made extraction more precise, with lower impact. But most of these were targeted to discrete issues, usually at a local level.

Carbon emissions are more diffuse and the effects are more distributed, without a direct link to the source. Addressing them requires coordinated efforts across firms, sectors, and nations, since no single company can change the course of an entire industry. As the links to emission-intensive industries and their products become clearer, public pressure mounts and investment capital for future projects becomes more difficult to obtain. Market caps have not kept pace with other industries, and so these industries represent a smaller portion of the economy *(see Figure 2)*. ENR firms need to find ways to respond while continuing to provide the materials and services necessary for consumers to enjoy the same level of personal consumption.

Market caps have not kept pace with other industries, and so the energy and natural resource industries represent a smaller portion of the economy.

Figure 2: The market cap of major energy and natural resources companies has grown in the past decade, but much less than in other industries

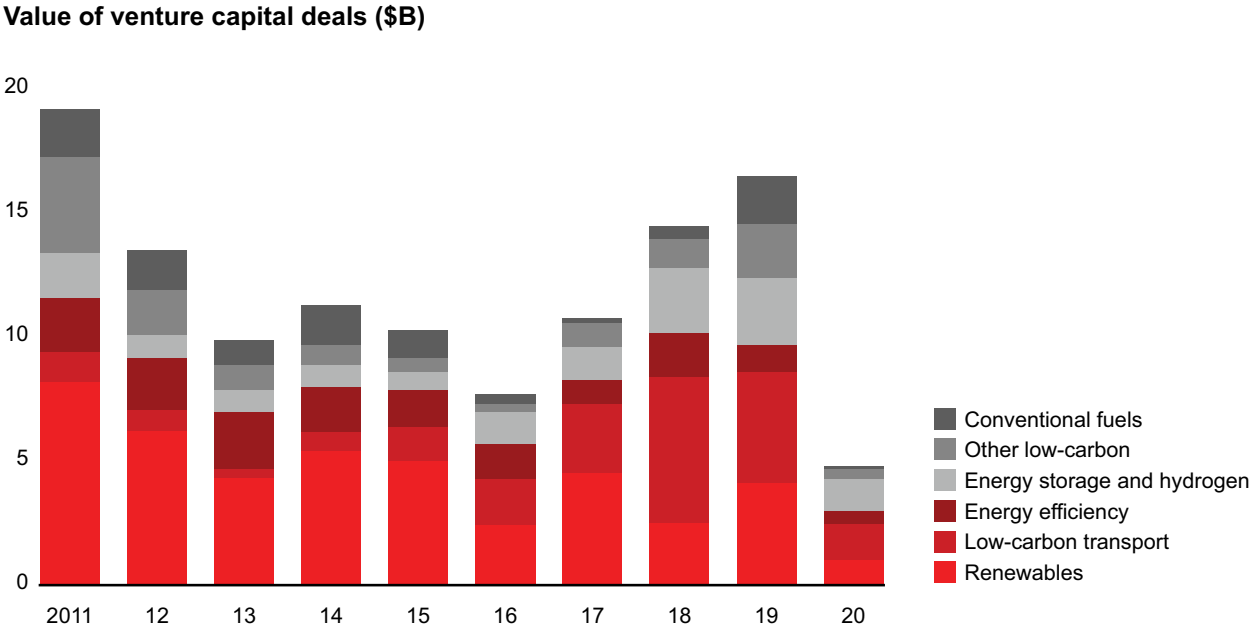


Sources: S&P Capital IQ; Financial Times; World Federation of Exchanges

At the same time, these firms must meet the needs of investors who control the price and flow of capital. The last decade has seen equity investors shift capital away from energy and natural resources firms and into technology, a sign that they lack confidence in the sector's ability to adapt to changing demands *(see Figure 3)*.

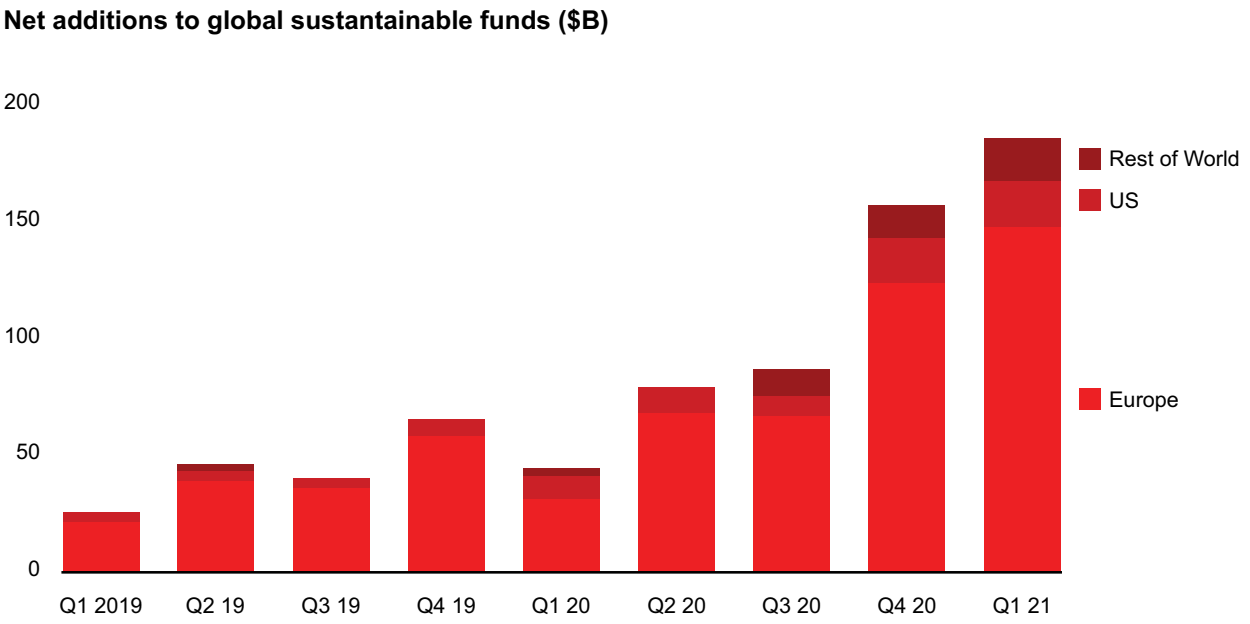
Restrictions on where and how capital can be deployed complicate this challenge. Funds focused on environmental, social, and corporate governance (ESG) objectives have grown *(see Figure 4)*. By April 2021, BlackRock, Vanguard, State Street, and 84 other fund managers had committed $37 trillion of assets to the Net Zero Asset Managers initiative, calling for net-zero GHG emissions by 2050. These firms can use their voting power to push proposals calling for meaningful changes. Banks and other financial institutions are also more reluctant to finance or insure assets or companies that aren't sustainable. JP Morgan Chase, for example, has said it would begin to measure the carbon intensity of its clients and use its influence to urge them toward more sustainable businesses. For ENR companies to maintain their access to capital markets and thrive over the next few decades, they'll need to show they can profitably execute a robust, multifaceted vision of global sustainability.

Figure 3: Over the past 6 years, venture capital has shifted from renewables to low-carbon transport



Source: International Energy Agency

Figure 4: More money is flowing through ESG funds



Note: ESG refers to environmental, social, and corporate governance
Source: Morningstar Direct, as of March 2021

Innovation, impact, and economics

Progress over the next five years will set the course. Incumbent players in energy and natural resources will either become leaders or continue to lose the public's faith and the support of the capital markets. Companies are showing early signs of effectively making the transition when they get three things right: innovation, impact, and economics.

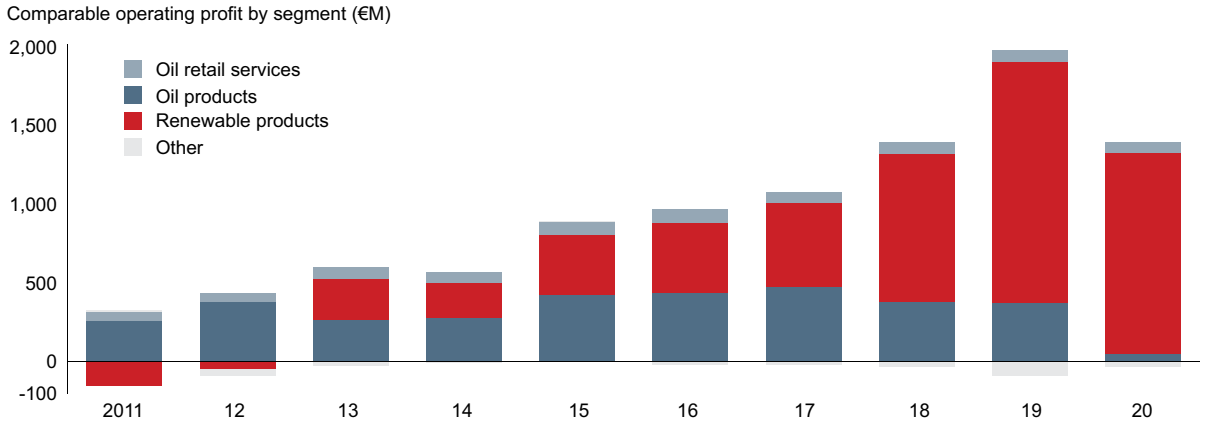
Innovation. Energy and resource firms are constantly innovating to create changes in society and markets, such as improving extraction methods to draw more hydrocarbons out of stubborn rock or developing more sophisticated plastics to replace heavier and more resource-intensive materials in vehicles. Now they're investing in innovation that will change their operations, supply chains, and products, moving toward a more sustainable, lower-carbon future. In some cases, they're fast followers of insurgents that have pioneered new techniques and technologies that could threaten existing business models. In other cases, they're developing their own innovations.

In Finland, refiner and chemical producer Neste has invested in innovative technologies and business lines to become the world's largest producer of renewable diesel fuel. More than a decade ago, Neste's leadership recognized the mounting risks of depending on traditional petroleum products as the fuel source of the future. Predictions of peak oil weren't just academic; they spelled the end of

growth. In response, the company invested in technologies to produce diesel from renewable sources. Renewable diesel now furnishes most of Neste's profits, but its eightfold increase in market valuation over the past decade results not only from this major new business line, but from other prospects stemming from it, including alternative aviation fuels *(see Figure 5)*.

Impact. Pressure is increasing on nearly every company to reevaluate its role in the local and global communities, and to become better corporate citizens. For ENR firms, most of the scrutiny focuses on emissions and other ESG issues like water use, waste, recycling, and transparency. In the long term, however, they're likely to be judged on a broader scorecard that includes their impact on native lands, environmental justice, and issues of diversity, equity, and inclusion. Most will need to retrain their workforces for a more automated future. To navigate this transition, ENR leadership teams must work with investors, customers, and communities to ensure they maintain the social license required to operate complex businesses in the world's most vulnerable places.

Figure 5: Most of Neste's profits come from renewable products



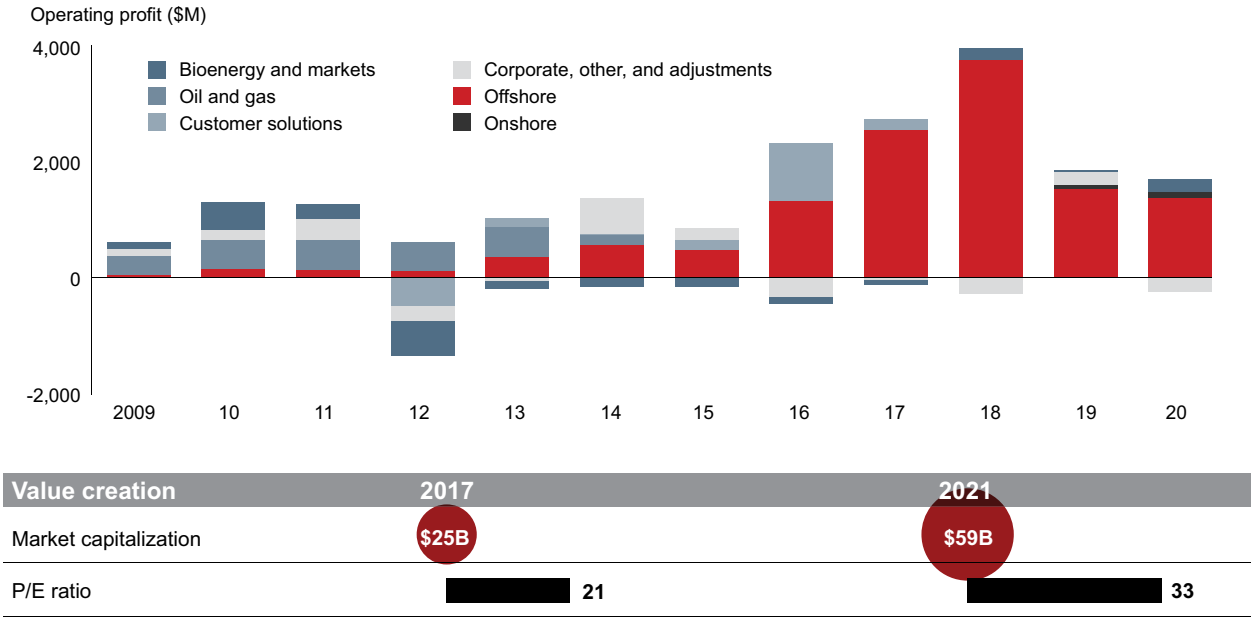
Value creation	2011	2021
Market capitalization	$5B	$38B
P/E ratio	7	44

Sources: Company reports; Bain & Company

In Denmark, the state oil and natural gas company, Dansk Olie og Naturgas, found that shareholders, customers, and other citizens were increasingly hostile to large carbon emitters, putting its long-term existence in doubt. In the first decade of the 2000s, after having already increased its presence in power generation and distribution, its leaders adopted a climate strategy that eventually led it to recapitalize the company, divest its oil and gas assets, and invest heavily in wind farms. Now rebranded as Ørsted, the company is a global leader in renewable energy delivery, with nearly all of its profits from wind *(see Figure 6)*.

Economics. You can't change the world if you can't fund the change. But forming the capital for new investments in the energy and resource transition increasingly requires not just hitting your marks on performance and earnings, but also telling a credible investor story, showing real leadership and the potential to create new value.

Figure 6: Ørsted's core business has recentered on offshore wind farming



Sources: Company reports; Bain & Company

The six largest banks in the US have pledged to provide financing only to zero-carbon projects by 2050.

Meanwhile, the funding and underwriting bars are rising. The six largest banks in the US have pledged to provide financing only to zero-carbon projects by 2050, and combined they have set aside trillions of dollars to fund green projects. Major insurers have balked at underwriting coal projects, and coal companies are reporting higher debt costs. Oil sands players in Alberta are also reporting challenges getting insurance. With more reporting requirements related to climate risk, and more discussions about stranded costs, the challenges in forming capital in fossil fuels will continue to grow.

However, the energy and resource transition can also be a real opportunity for those willing to embrace it. Duke Energy, a large multistate utility in the southeastern US, has improved its operational performance and announced the largest power generation transition in the country. This transition, which will reduce Duke's active coal units by 50% to 70% by 2030, is an important component of a $124 billion to $134 billion capital plan for 2021 to 2029. Duke's announcement, accompanied by an ESG Investor Day and a higher rate of growth for earnings, helped drive share prices from the mid-$80s in May 2020 to more than $100 in May 2021.

So far, Neste, Ørsted, and Duke Energy are among the exceptions. Few other companies have moved quite so assertively to confront these issues. It's worth noting that the fast movers play in industries where the externalities are most obvious and the threats to success seem most imminent: energy and power generation. But others aren't immune. In agriculture, for example, the popularity of Beyond Meat and Impossible Burger have spurred nearly every major food company to invest in alternative proteins.

While there's no repeatable blueprint, we're already seeing patterns that can set companies up for success. Firms with steady core businesses are using revenues to invest in second engines of growth, new lines that make good use of their capabilities while tapping into new markets. Others with products that remain in high demand are investing in R&D and product development that will allow them to continue selling into growth markets while reducing emissions or other harmful effects. And nearly every firm is developing a roadmap for achieving the ambitious sustainability goals that most have announced in recent years.

We wrote this report to share what we're seeing in the marketplace and to show what some companies are doing to make the most of it.

The first section describes some of the important trends affecting energy and resource companies today:

- Public-private cooperation in climate policy
- Other, nonenergy transitions that are occurring
- Redesigning the value chain to meet consumers' evolving preferences
- The need for a more collaborative relationship between ESG investors and ENR firms
- Early business cases for hydrogen

The second section outlines some important tools and capabilities to help manage these transitions, equipping executives with:

- More effective methods for managing capital projects
- Ways to measure operations and supply chains on more parameters than just cost efficiency
- Strategies for developing an Engine 2 of growth
- A four-step process for accelerating the journey to net zero
- Digital technology's role in freeing up capital for investment in the energy transition

The task ahead may appear daunting, even for the most capable energy or natural resources executive. But the tools to thrive in this period of rapid change—the capabilities to innovate, an understanding of the impact on shareholders and communities, and the ambition to pursue the economic opportunities inherent in the transitions—are all within reach. Those who continue to deliver on their current business while developing longer-term plans will be the ones who turn an existential threat into the opportunity of a generation.

Critical Trends of the Transition

Critical Trends of the Energy and Natural Resources Transition

Net Zero: From Political Goals to Industry Action

In Denmark, a partnership between government and the private sector offers a model for successful collaboration on decarbonization.

By Thomas Arentsen, Alessandro Cadei, Grant Dougans, and António Farinha

At a Glance

- Most of the world's major economies and many of the largest companies have set goals to reach net-zero carbon emissions over the next 30 to 40 years.
- While discussions about reaching those goals deals largely with abatement curves and net-zero studies, the actual steps to get there have more to do with raising capital and reducing risk.
- One model for public-private cooperation to reduce risk is Denmark's climate partnerships, in which policymakers and companies share responsibility for moving toward net zero.

Over the past few years, most of the world's large economies have set targets of reaching net-zero carbon emissions over the next 30 to 40 years. To achieve these ambitious goals, investments in green technology are ramping up quickly and could surpass conventional energy investments in 5 to 10 years. It's an impressive shift, but one that's still too slow to meet the Paris Agreement's goals of keeping the rise in temperature below 2.0°C in this century—unless the private and public sectors learn to work more collaboratively to encourage capital investment and reduce risk.

The roadmap to reach net-zero emissions is clear, and we can think of it in terms of four categories, each comprising a range of actions.

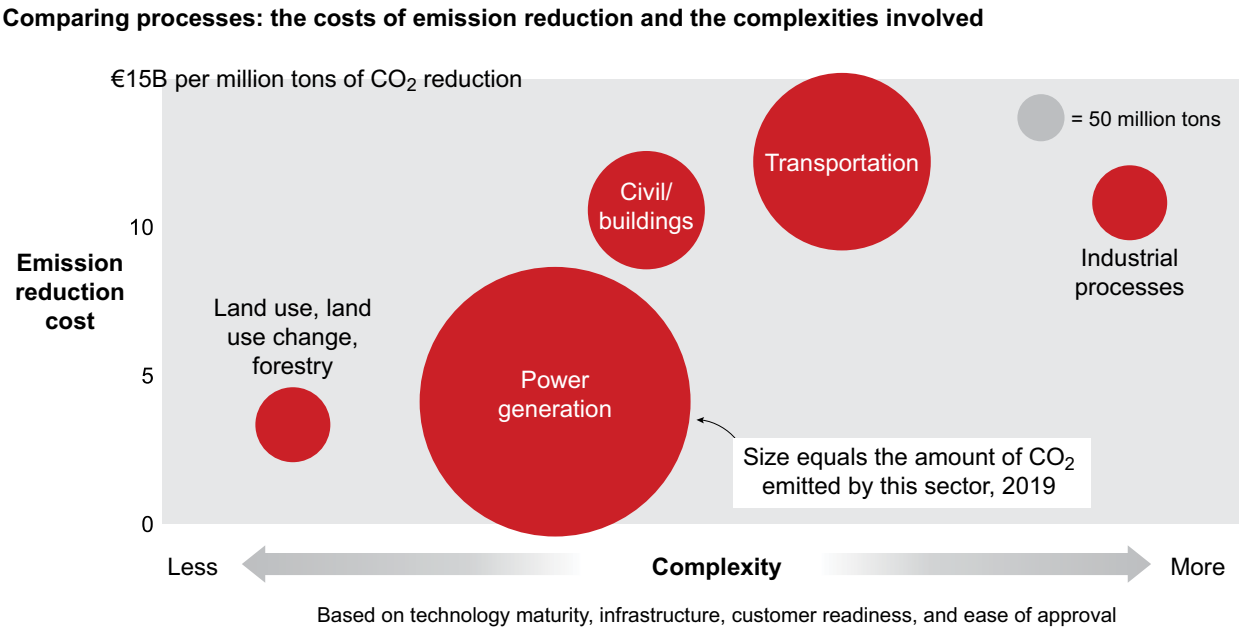
- **Consume less energy.** Reduce waste in buildings and industrial settings, and make appliances and the electricity grid more efficient.
- **Decarbonize or electrify.** Switch from internal combustion engines to cars and trucks that run on electricity or other low-carbon fuels. Electrify heating and industrial systems.
- **Green the electricity supply.** Build more renewable power generation and other zero-carbon sources of energy and capacity.
- **Capture and store carbon.** Build systems that capture CO_2 and other greenhouse gases during production and directly from the atmosphere. Preserve and enhance natural carbon sinks, such as forests.

To make this happen, electric grids need to be updated, gas and district heating systems will change, and energy consumers have to embrace new technologies. Electrification will play an important role, but it won't be enough on its own. Fuels from low-carbon hydrogen need to be developed to meet some transportation and industrial needs (see "Business Opportunities in Low-Carbon Hydrogen.") By some estimates, $50 trillion will be invested over the next 30 years in renewable energy, hydrogen, electrification, carbon capture and storage, biofuels, and infrastructure to support it all.

Much of the discussion on reducing emissions focuses on abatement curves and net-zero studies. While these help countries and industries think about where they have to go, getting there has more to do with encouraging capital and reducing risk. A look at nonagricultural emissions in the European Union through the lens of capital intensity and complexity shows where some of the big opportunities are, and where the private sector probably needs more support to reduce the risk of large investments *(see Figure 1)*. In some sectors, such as power generation, the technology to reduce emissions is already well known, and the required capital investment is within reach for much of the private sector, given the right policy constructs and pricing mechanisms. However, in other sectors, where the complexity and costs remain high, such as transportation and industrial processes, managing risks will require public and private partnerships.

While the steps are clear, what's missing is a unified approach among industry, policymakers, customers, and capital to move the world from lofty ambitions to real climate action.

Figure 1: Power generation offers the greatest potential for rapidly reducing Europe's CO_2 emissions, while some transportation and industrial processes will require more support



Notes: Emissions measured within European Union; doesn't include agriculture.
Sources: European Environment Agency's Emissions Database for Global Atmospheric Research (EDGAR); national climate plans; Bain & Company

Denmark's national collaboration model

One model taking shape in Denmark shows how the government and the private sector can work together to promote capital formation, foster innovation, and share risks in order to move closer to that country's goal of reducing emissions to 70% of 1990 levels by 2030, and net zero by 2050.

In the Danish government's climate partnerships, policymakers provide the framework and conditions, while business contributes its expertise and the investment in new technology and infrastructure to meet the country's climate ambitions.

The partnerships include energy companies in oil and gas and renewables (both utilities and original equipment manufacturers in wind, solar, biogas, and hydrogen), and companies along the grid, including transmission, distribution, and retail. The initial work has set ambitious goals for 2030, including reducing carbon emissions from the energy and utilities sector by at least 95%; cutting fossil fuel use in buildings, transportation, and industry by 50%; and developing a 10-year roadmap for hydrogen fuels.

In the partnerships' work, risk sharing emerged as an important topic. Because energy companies invest heavily in infrastructure and generation, which often take decades to repay and are designed

to last even longer, the private sector wants to ensure that the political will exists to create demand for greener energy and products. But altering consumption habits can be difficult. Prices of fossil fuels and other energy sources will help guide some changes, but for others, incentives, subsidies, and regulations may be necessary.

To reach Denmark's target of reducing carbon emissions to 70% of 1990 levels by 2030, the country would need to generate twice as much electricity as it does today, which would require significant investments in renewable energy production and infrastructure, along with investments in new technology by industry. An analysis by Bain and the Danish Energy Association found that the country could completely phase out fossil fuels in electricity and heating, delivering clean energy to industry, agriculture, and transport.

The partnership provided a way for business and government to speed up progress toward net zero by combining strengths.

One of the partners is Danish energy company Ørsted, whose group CEO, Mads Nipper, highlighted the need for political and business collaboration. "Fixing climate change is not a technology problem," he said. "We pretty much know the solutions to do it, and there is plenty of financial capital available. But we have a leadership problem, and it's becoming increasingly important for business executives to take on the role as key influencers in shaping policies and national climate actions."

The partnership provided a way for business and government to speed up progress toward net zero by combining strengths. In the initial phase, the government gave up some control to business executives, which created trust and ownership in the business community. "This work could never have been completed effectively by government alone, and would not have succeeded without the acknowledgment of all participants of their responsibility for the outcome," said Lars Aagaard, CEO of the Danish Energy Association.

Denmark has taken important steps toward realizing its politically determined climate targets through actions that haven't scared off the business community. Building on the work of the partnerships, the government approved laws aimed at bringing Denmark a third of the way to its 2030 targets. Executives have been able to create a productive alliance with government that looks at opportunities and threats to achieving the country's climate goals in a balanced way, and with regulatory tools that support new business opportunities.

Unlocking the net-zero opportunity

For energy and natural resources companies, the key to this level of cooperation is improving the way they work with stakeholders and policymakers. Even small policy decisions can have multi-billion-dollar effects on a large company's energy transition. Policymakers, business leaders, and other stakeholders have to get better at resolving disputes, sharing risk, and clarifying the rules of the road—which all will be important in allowing companies to obtain the capital needed to invest in new technology.

These dialogues and perspectives need to make their way into and across energy and natural resources organizations. Adopting the stakeholder view can't be left to the regulatory or legislative affairs teams; it must be a fundamental consideration that influences decisions about capital planning, operations, R&D, and product development. That's the surest way to guard against company silos continuing to conduct business as usual while stakeholders and policy makers push the company in a different direction. Everyone should be aware that the stakeholder landscape is changing and understand their role in navigating it.

Collaborating closely with stakeholders is but one of the transformations required of executives at energy and natural resources companies. These executives can think about five imperatives to help capture new opportunities and move toward net zero.

- Make the shift to green technologies, whether from fossil to renewables, or from analog to digital.
- Shape the stakeholder landscape to create constructive policies and remove impediments to capital deployment.
- Engage actively with customers to capture their interest in green products, and to enlist their help in decarbonizing and reducing energy use.
- Prepare for new levels of capital deployment and scrutiny, from major capital projects to programmatic investments.
- Make sure corporate culture and processes are ready for the net-zero transition, including leadership and cultural norms, management systems, structure, accountabilities, talent strategy, and business processes.

Unlike in digital, where companies often set up use case factories to accelerate progress, this transformation must be deeply felt and embedded throughout the organization, with every employee—and the hard work of getting underway should start now.

Critical Trends of the Energy and Natural Resources Transition

Energy Is Only One Part of the Sustainability Transition

Energy and natural resources companies are responding to seismic changes in transportation, plastic, and how we grow and consume food.

By Jayant Gotpagar, Fernando Martins, Peter Meijer, and Mark Porter

At a Glance

- In addition to changes in energy, companies are managing other large transitions that will affect their core businesses and offer new paths for growth.
- The shift from internal combustion engines to electric vehicles affects not only automakers and energy companies, but chemical, mining, and agriculture companies as well.
- Chemical producers must respond to the global push to reduce plastic waste. Bio-based polymers can produce plastics with fewer emissions, while other innovations will create more recyclable or biodegradable products.
- In agriculture, fertilizer is coming under scrutiny for its emissions, and agribusinesses are addressing consumers' changing diets, including alternatives to meat.

The energy transition is already roiling the energy and natural resources (ENR) sectors, affecting long-term strategic planning, investments in infrastructure and equipment, allocation of resources, and so much more. But this isn't the only resource transition that ENR companies are dealing with. Several others are in motion, aimed at reducing waste and improving the circularity of supply and production chains, and developing a more sustainable food supply to feed a growing population. Like the energy transition, these will transform the way ENR companies do business—and executives will have to adapt their business strategies and operating models in order to thrive.

These transitions all reflect shifting attitudes about the roles of industry, government, and consumers in managing resources. Consumers and shareholders are, increasingly, demanding change and accountability. As companies react, profit pools are bound to shift, and executives will want to identify these trends before they happen.

Leading companies will need to balance the needs of their existing core business while building new sources of growth. To succeed in their new lines of business, they'll have to identify customers' evolving needs and develop a differentiated position that addresses them. Some of their bets will be large, others small, and not all will pay off. To fund these second engines of growth, leaders will often reduce the costs of existing operations while making necessary improvements to the operating model, deploying innovations in operations and products.

To help develop a better understanding of these transitions, Bain looked at four that are underway:

The shift to electric vehicles (EVs). Much has been written about the effect of EVs on the oil industry and renewables, but the chemical, mining, and agriculture sectors are also adapting.

Ending plastic waste. Chemical makers and other companies in the industrial and consumer sectors will have to work together to improve the circularity of plastic and reduce pollution.

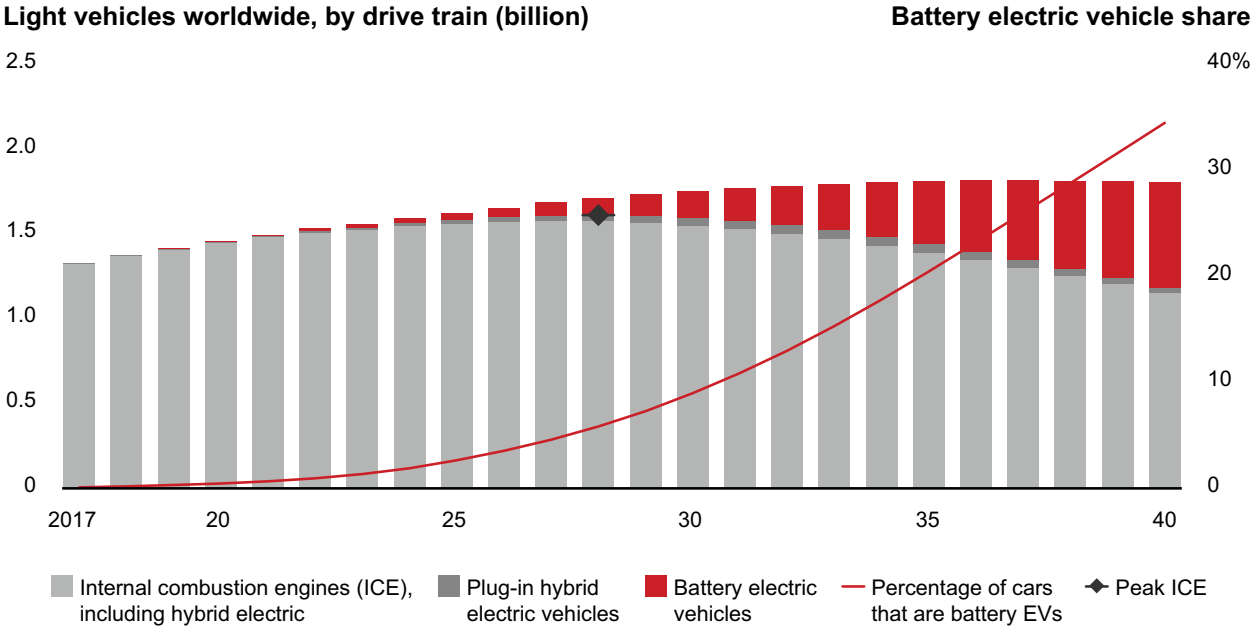
Decarbonizing the fertilizer chain. A price on greenhouse gas (GHG) emissions and rising demand for ammonia in other applications such as marine fuel will increase the cost of fertilizer, setting off a chain reaction through the chemical and agricultural sectors.

Responding to a changing diet. As more consumers adopt diets with less meat, the agricultural industry is investing in alternative proteins.

From vehicle exhausts to batteries, from platinum to lithium

The transition from internal combustion engines (ICEs) to electric vehicles is causing ripple effects across supply chains and into the chemicals, mining, and agribusiness sectors *(see Figure 1)*.

Figure 1: Internal combustion engines could peak by 2028, as battery electric vehicles grow to 35% of the global fleet by 2040



Source: Bain EV market model

In chemicals, volumes may have peaked for the exhaust systems used in ICEs, which rely on chemical catalysts. Until now, stringent regulations have required automakers to use more chemical catalysts, resulting in a higher value per average vehicle. In fact, the total value of chemical catalysts in exhaust systems grew 7% per year since 2010. Over the coming five years, however, growth is expected to slow to 2% per year, and the global market may shrink afterwards.

This gloomy outlook has pushed the leading material suppliers—BASF, Johnson Matthey, and Umicore, which supply more than 90% of the market—to invest heavily in innovation by developing materials that will be needed for future power trains. These investments include cathode-active materials for batteries, which account for more than 30% of the battery's cost, and membranes for fuel cells.

This pivot taps capabilities that suppliers already have, including fine metals chemistry and relationships with the automakers. They also must develop new muscles to succeed in markets with greater competitive intensity, faster development cycles (battery costs per kWh fell by more than 85% from 2010 to 2019), and large capital investment demands, around $1 billion for a scale factory. It also disrupts traditional, linear value chains and requires greater flexibility to work in constantly changing partnerships with more companies.

Mining companies will also be affected. The exhaust systems on ICE vehicles are the main market for the platinum group metals (PGMs), and while they're also used in fuel cells, the market for fuel-cell EVs isn't expected to be as large, resulting in less demand for PGMs in autos. As old ICEs are scrapped, their PGMs will be recycled. The net effect will be less demand for virgin PGMs, forcing mining companies to adjust.

On the other hand, more batteries will mean greater demand for nickel, lithium, and cobalt, with an average 60 kWh battery needing about 90 kilograms of these metals. As demand rises, so will prices of these metals.

Miners need to figure out their transition from a strong position in PGM mines to a new position of strength, for example, increasing their access to mines that produce cobalt or rare earth minerals, with an eye to maximizing the value of their investments.

The ripples spread further. Corn farmers in the US Midwest will feel the pinch because about 40% of all US corn becomes ethanol, which is blended at about 10% into gasoline. Our baseline EV penetration curve implies a reduction of 45% in corn tonnage requirements for ethanol in the US alone. Much of that prime cropland could switch to crops that require fewer inputs, creating other ripple effects for suppliers and retailers. In addition, some of the world's ethanol mills could become stranded assets.

Changing how we create, use, and discard plastics

Plastics have come under increasing scrutiny due to the increase of plastic waste, which has created huge environmental challenges. However, many of the alternatives to plastic (including paper) can increase carbon emissions as much as five times. Plastic packaging also helps to extend the shelf life of perishable food, thereby reducing food waste, which is another major contributor to carbon emissions. Optimizing both waste and emissions involves complex trade-offs that are amplified as environmental, social, and corporate governance (ESG) targets for producers and customers of plastics become more ambitious.

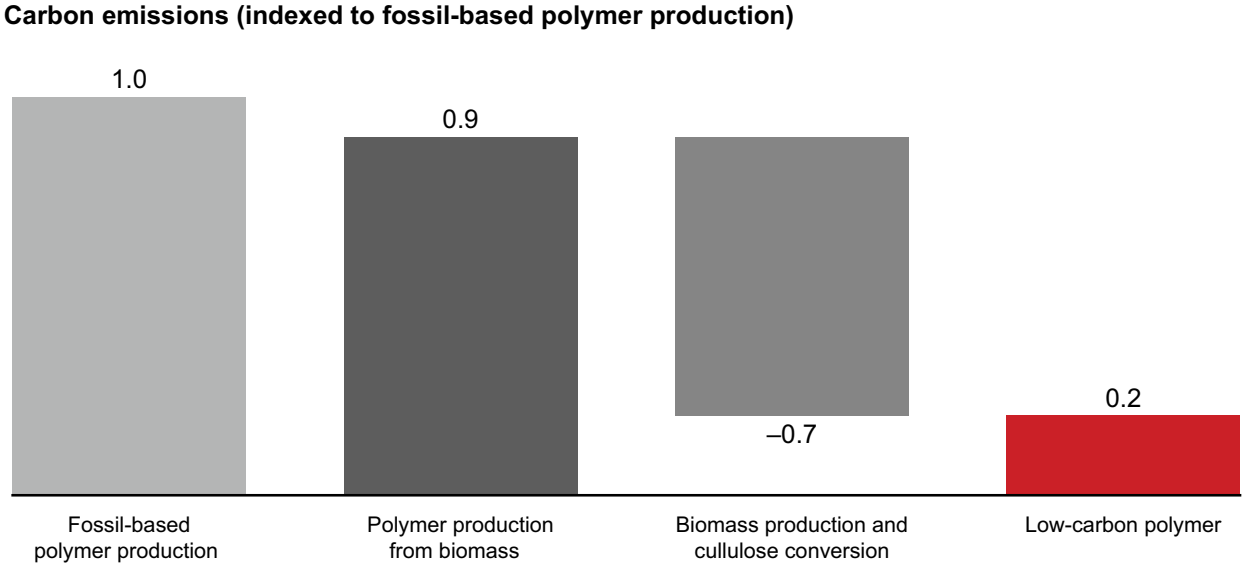
There's no silver bullet, of course. For each product or process, multiple solutions exist, each requiring trade-offs on product and environmental performance. Ultimately, we'll have to change how we create, use, and discard plastics, and that will require innovations in technology and business models. This starts by understanding consumer needs for individual applications and finding the right alternatives to meet them. The solutions will combine ways to reduce the use of plastics where the application isn't critical, replacing some of today's plastics with bio-based or biodegradable plastics, improving recycling, and introducing alternative materials.

Producers of plastics are aiming to develop materials that are more recyclable and emit less carbon over their life cycle.

Producers of plastics are aiming to develop materials that are more recyclable and emit less carbon over their life cycle. The accounting for reductions in emissions isn't yet standardized, but compared with virgin materials, recycling appears to emit less emissions during production and avoids emissions from products that end up in landfills. At the same time, packaging companies, retailers, and consumer products companies are designing products and packaging to improve traceability, compliance, and labeling of recycled content.

Bio-based plastics, which are made entirely or partly from renewable biological materials, are a solution that primarily addresses plastic process emissions. By using renewable biomass, which would otherwise decompose to produce methane (a powerful greenhouse gas), the life-cycle emission for a bio-based polymer can be reduced by 80% or more *(see Figure 2)*, or even end up negative. Another approach is to combine hydrogen (made with renewable energy) with carbon dioxide to

Figure 2: Low-carbon, bio-based polymers emit significantly less carbon than polymers made from fossil-fuel feedstock



Notes: Polymer life-cycle analysis based on kilograms of CO_2 emitted per kilograms of polymer produced; negative emissions represent use of biomass material that would otherwise go to waste, decompose, and release methane; polymer production from biomass produces less carbon across the entire process than polymer production from petroleum-based feedstock; carbon measurement and accounting methods aren't yet standardized, so others' findings may differ
Source: Bain & Company

produce simple hydrocarbons that can then be turned into plastic—again creating a carbon-negative material.

Tackling the problem of plastic waste and emissions will also create new opportunities. Waste collection, sorting, and recycling requires major investment and technological innovation. Given the scarcity of high-quality plastic waste as feedstock for recycling, those who identify and develop markets for recycled materials will have a first-mover advantage. New profit pools may open up with market entrants, customers, and applications that draw investments to build scale and support a more circular value chain. Companies will need to continue shrinking costs in the core resin business to stay competitive and enable investments in new solutions.

Since no one player can solve these crises alone, plastics producers, converters, and brand owners need to think beyond the boundaries of their traditional value chain. Some will view sustainability as a limited action plan, but long-term winners will embrace sustainability as integral to their strategy, building on their strengths and finding partners with complementary capabilities.

Redefining the fertilizer chain

The production and use of fertilizer create about 2.5% of total greenhouse gas emissions. Fertilizer producers and growers have several options to mitigate emissions, including low-carbon feedstock (using ammonia made with blue or green hydrogen), shifting from commodity fertilizers to specialty NPK (nitrogen, phosphorus, and potassium) compounds and nitrates with more sophisticated dosages, deploying specialized seeds, switching to organic fertilizer, and adopting regenerative agriculture practices.

Governments may be cautious about prioritizing these emission reductions if they'll increase food costs for consumers.

These alternatives add cost, and it's not clear how quickly growers will shift to lower-carbon alternatives. Governments may be cautious about prioritizing these emission reductions if they'll increase food costs for consumers. But eventually these shifts are likely to materialize, and demand will slow for commodity fertilizer producers.

Other changes will also disrupt business models and profit pools. Feedstock competitiveness could shift from regions with cheap natural gas to those with cheap renewable energy when green hydrogen becomes a bigger part of the supply. Specialty fertilizers will demand more customization and integration with customers. And the industry's by-product revenues could erode as production processes change, reducing the supply of secondary products such as diesel exhaust fluid (DEF) or CO_2,

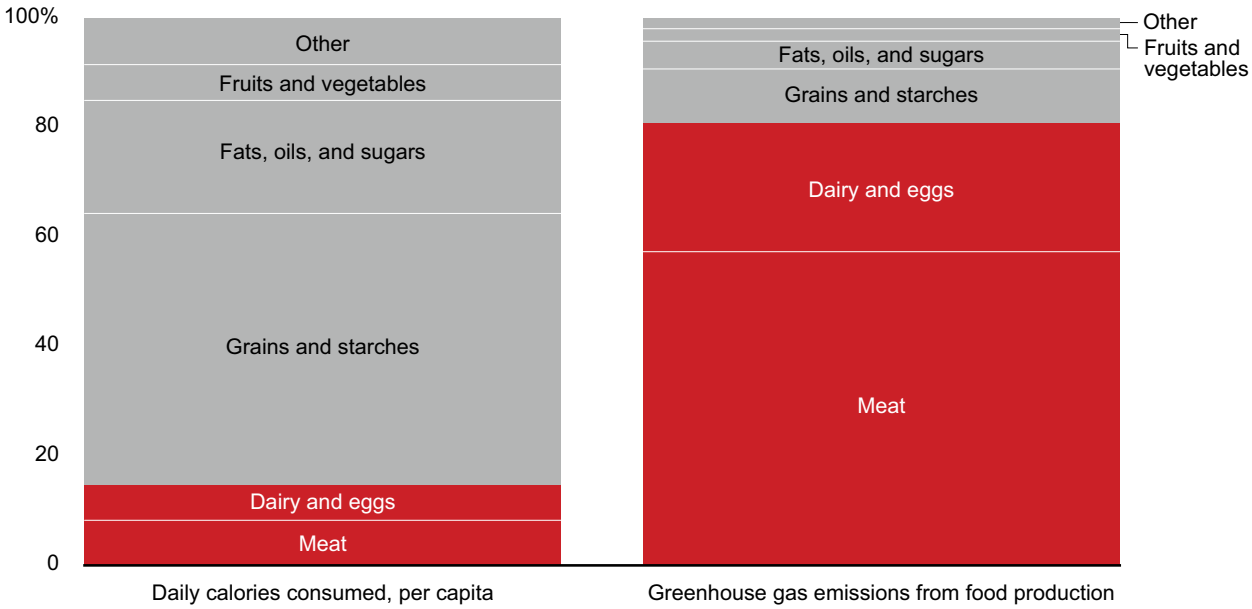
which is often sold off today. Emerging demand for ammonia as a zero-carbon shipping fuel may provide growth opportunities for companies that make ammonia-based fertilizers.

Leading fertilizer producers are preparing for change, identifying their future positions in the commodity fertilizer market and determining what they need to do to continue delivering attractive returns. For most, this means reducing costs while investing in new products like specialty fertilizers. Their market and sustainability ambitions will inform these decisions. Finding ways to build on their current capabilities in production, logistics, and innovation will help them balance their progress in new growth areas with their current business in commodity fertilizer.

Responding to a changing diet

About 20% of all nutritional and caloric needs globally come from land-based animal protein sources: meats, eggs, and dairy products. Proteins are associated with healthy nutrition, growth, and balanced diets, and most governmental nutritional guidelines around the world encourage significant protein in diets. Yet those land-based animal proteins also take a toll on resources, accounting for about 14.5% of greenhouse gas emissions in agriculture and 80% of all food-related GHG emissions worldwide *(see Figure 3)*. They use about one-fourth of the water and 80% of the land dedicated to food production.

Figure 3: Meat and dairy are a small part of global food consumption, but emit about 80% of the greenhouse gases from food production



Note: Annual global emissions from food production total 7.2 gigatons of CO_2 equivalent
Sources: Food and Agriculture Organization Corporate Statistical Database; UNESCO; Bain & Company

Innovations in protein production and consumer packaging could reduce that resource intensity over time. Four lines of technology are particularly promising because they all deliver taste and texture similar to current proteins, and could cost about the same as the real thing in 5 to 10 years:

- **plant-based dairy and meat alternatives**, building on food technologies that have existed for a few decades, such as protein isolation and extrusion;
- **precision fermentation of selected proteins in milk and meat**, to enhance the taste and texture of the plant-based milks and meats;
- **cultivation of tissue cells (or cellular protein agriculture)**, getting animal tissue cells to replicate, grow, and specialize in bioreactors; and
- **mycelium fungus** to simulate meat, especially pork or beef cuts.

The future of protein will probably combine these technologies, and as they become more cost-competitive, they may replace 15% to 35% of animal protein in the US by 2030 to 2035. Awareness of plant-based alternatives to meat has never been higher, following the successful introduction of several popular consumer brands. Precision fermentation should increase their appeal. Over time, cell cultivation will deliver ground-meat products nearly indistinguishable from the real thing. If mycelium and other materials prove adequate as scaffolding for cultivated cells, the disruption to protein will be even greater.

These technologies are undoubtedly a threat to incumbents, but also present an opportunity to tap a bigger pool of consumers and increase product innovation while reducing costs and resource footprints. Protein players have taken notice. Tyson Foods in North America and Fonterra in New Zealand have taken equity positions in promising insurgents in alternative meats and dairy. JBS, BRF Global, Vion Food Group, and Marfrig (in partnership with ADM) have developed or launched product lines. Kellogg's and Kraft Heinz in the US have launched product lines and brands or are pivoting existing ones. Some other dairy and meat companies are heading the other way, proudly retrenching into the higher-end segments of the core protein market where, they believe, demand will remain strong for things like grass-fed Angus beef, cage-free eggs, organic beef and dairy, high-fat and high-protein yogurts, and artisan cheeses.

These companies and other incumbents should consider how to integrate new technologies into their core businesses. If, in the future, consumers get clean, safe meat from vats and reactors, an intermediate step will see old and new technologies coexisting, sometimes in the same facility. Bringing the investments and capabilities to scale production of alternative proteins will help the industry accelerate the resource transition, and help early adopters establish a foothold with key customers in the food and retail industries.

How to act

For every company, balancing the needs of the current business while investing in innovation and new product lines will become a key strategic task. Five actions can help executives get started.

- Develop a perspective on existing profit pools and your path to new ones.
- Move quickly to gain experience and build a leading position before the rest of the market catches up. Partnering with other companies along the value chain can speed up this process and fill capability gaps.
- Develop the commercial proposition for customers' evolving needs and determine which changes you need.
- Align your operations, including purchasing, supply chain, manufacturing, and planning, to meet new customer demands.
- Update the way teams work in your company, emphasizing the need for more cross-functional coordination, and adjusting resource allocation to consider both long-term priorities and short-term demands.

Managing these priorities over what could take decades may feel overwhelming. The best way to get started is to clearly define long-term goals, root out the new opportunities, and begin building the muscles necessary to capture them.

Critical Trends of the Energy and Natural Resources Transition

Redesigning Value Chains to Deliver More Sustainable Goods

The companies that know their customers best aren't always the companies that need to change the way food and products are developed.

By Sasha Duchnowski and Jessica Snow-Wasserman

At a Glance

- Consumers are becoming more willing to pay a little extra—usually 5% to 10% more—for food and other products that meet their requirements on social responsibility, inclusiveness, or environmental impact.
- This presents an opportunity for companies that can develop and sell sustainable products at a premium within that range. A 10% increase in the cost of sustainably raised wheat would add only a few cents to the price per loaf of bread.
- However, the companies that know the customer best—retailers and brands—aren't always equipped to address consumers' concerns without cooperation from upstream partners.
- Companies are rethinking the value chain, developing closer partnerships upstream and downstream, so that all can better understand and meet the needs of customers.

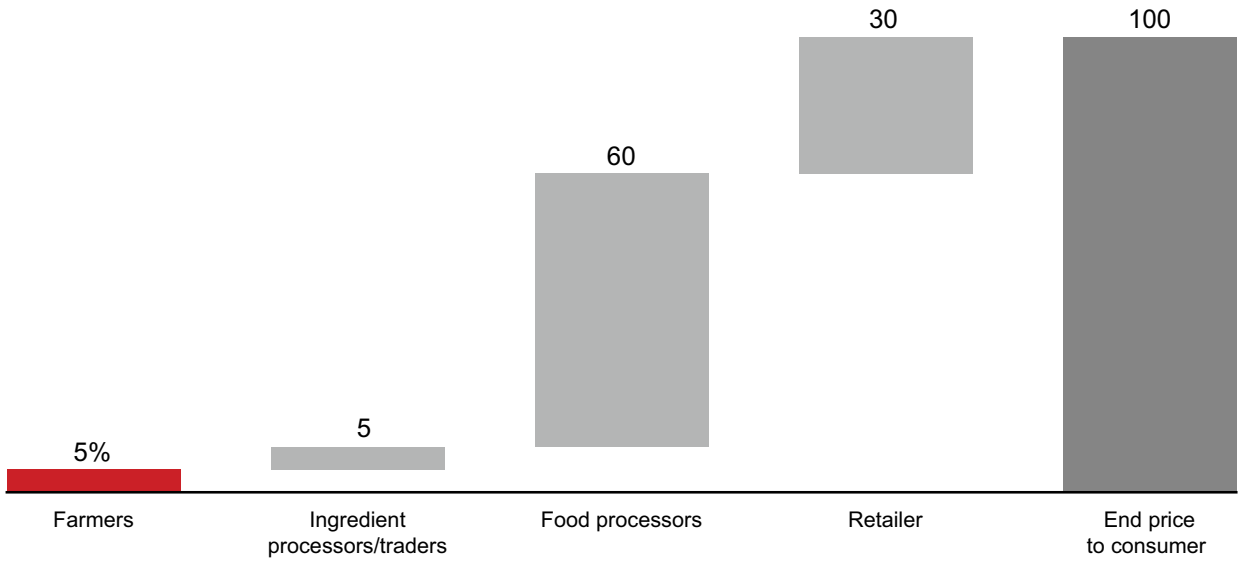
In discussions about making food and other input materials more sustainable, the fists banging the table have been forceful, but consumers have been more tepid in their response, mostly unwilling to pay for greener products.

That's beginning to change: Nielsen research finds that 81% of consumers worldwide feel strongly that companies should improve the environment, with the feelings strongest among Gen X, Millennials, and Gen Z, and shared to a lesser extent by older consumers. And they're walking the walk: A study by Sogeti Cap Gemini reports that 79% of consumers are changing purchase preferences based on social responsibility, inclusiveness, or environmental impact.

This is a big opportunity for food and other consumer product companies because this commitment suggests that customers will pay more for products that meet their requirements—although usually only 5% to 10% more. In some cases, that would be enough. If farmers could charge 10% more for wheat, they could invest that money in more sustainable practices, and the extra cost would increase the price of a $2 loaf of bread by only a penny *(see Figure 1)*. The math is similar in packaging, which usually makes up about 10% of the cost of a product. Even a 50% increase in packaging cost, for example to cover the use of recycled plastic, would increase the total product cost by only 5%—within the range of what consumers say they'll pay for greener products.

Figure 1: Farmers could invest in greater sustainability and be paid more, without significantly raising the price of the end product

Share of the cost for a loaf of bread



Sources: US Department of Agriculture; The Retail Owners Institute: Bain & Company

However, the companies that sell directly to customers are usually several levels removed from the growers and manufacturers that could make the changes consumers want. For example:

- **Growers** are fragmented and focused on meeting product specifications that give them access to local and global markets. Most adopt new practices only if they lower costs or help them create a more premium product.
- **Processors** are focused on reducing costs by growing bigger and standardizing outputs.
- **Brands** want to reduce the cost per unit and may not fully understand the upstream challenges in greening products.

How can companies work together to deliver more sustainable products at prices that consumers are still willing to pay?

In the past, consumer product and food companies have tailored their products to changing customer preferences, often to reduce prices or make products more convenient. Today's challenge is different: How can companies work together to deliver more sustainable products at prices that consumers are still willing to pay?

Successfully redesigning the value chain

Change is always hard in big companies, especially in sustainability. Bain's 2018 study of nearly 300 sustainability-driven change efforts paints a stark picture. Only 4% of sustainability programs achieved their full ambitions, 49% achieved diluted results, and the rest were acknowledged as failures.

How can companies beat those odds? In our work with companies redesigning value chain dynamics, we've noticed three factors that appear to increase the chances of improving sustainability in their value chains.

It starts with getting a better understanding of what customers want to buy this week and next year. Consumer brands and retailers are closest to customers, and more likely to understand their preferences. But to make the equation work, they need to work closely with suppliers and other partners across the value chain to communicate those preferences and innovate collaboratively to come up with new products and packaging.

For example, while food and beverage companies have always partnered closely with packaging companies, we're seeing better coordination now, as both sides develop packaging that appeal to

customers who want to see less waste. The result is lots of innovation in things like recyclable food trays for produce, recyclable coffee cups, and even refillable soda bottles—an old idea that's come round again. Coca-Cola has been investing in upstream suppliers to improve its plastic recycling capabilities. In 2019, Coca-Cola worked with a recycling technology firm, Ioniqa Technologies, and one of its packaging suppliers, Indorama Ventures, to develop a bottle made with 25% plastic recovered from the seas.

A second factor is that companies will move up or down the value chain if they think it will help them meet customer demand. In beer, for example, brewers sometimes take control of hop production, either directly or through contracts, to maintain access to supply and quality of this integral ingredient. In plastics, to scale up recycling, producers will need a reliable supply of used plastic for feedstock. For example, in 2020, renewable diesel leader Neste of Finland and Unilever teamed up with Recycling Technologies to develop a program to ensure a more robust supply of feedstock for plastics recycling programs in the UK. Recycling Technologies turns the plastic waste into an oil that it delivers to Neste, which analyzes it and upgrades it into feedstock for new, virgin-quality plastics. Unilever brings its insight on customer preferences and its expertise on packaging design to the program.

Finally, everyone will need an incentive to change behavior. The benefits of sustainability, including premiums charged for it, have to be shared across the value chain. The Nature Conservancy worked with tuna suppliers in the western and central Pacific to create a seafood company, Pacific Island Tuna Provisions, that has end-to-end control to ensure sustainable practices, including reducing bycatch of other species. One of the company's goals is to improve socioeconomic conditions among the Pacific Island communities that rely on sales of tuna. With electronic monitoring of its sustainable fishing practices, the company offers retailers and customers high visibility into its supply chain practices to ensure that it's following sustainable principles, in exchange for long-term, mutually beneficial supply contracts.

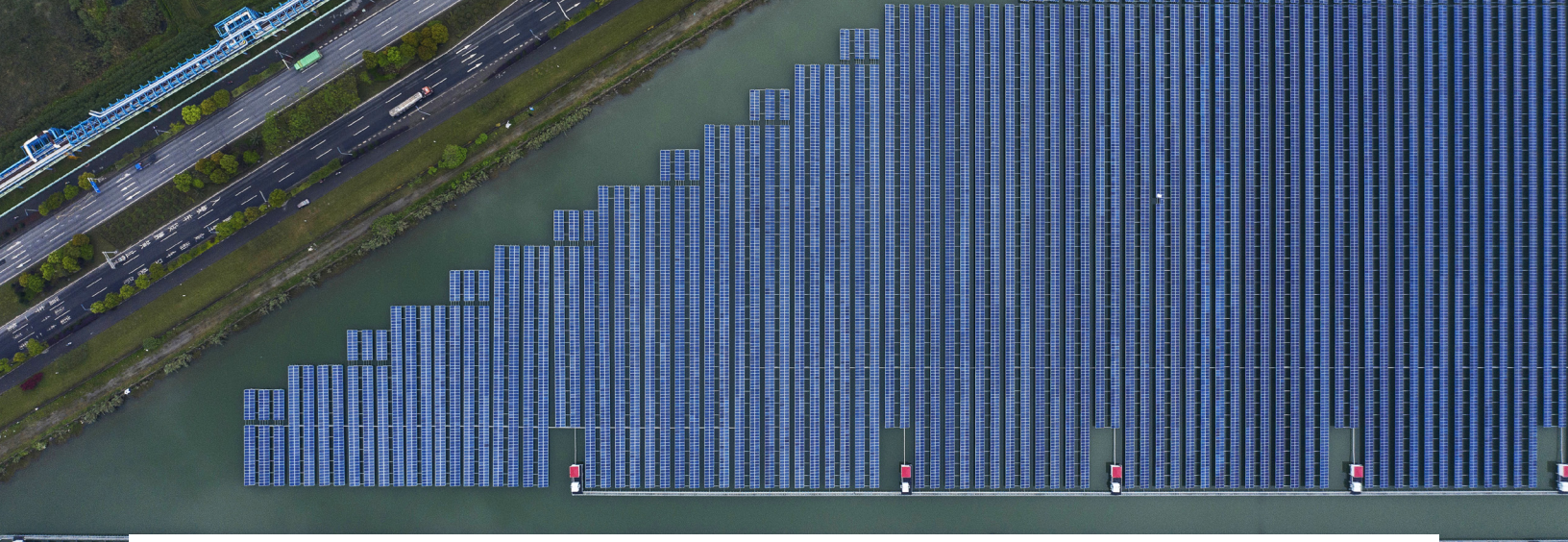
The benefits of sustainability, including premiums charged for it, have to be shared across the value chain.

Taking action

If understanding the customer is the first principle in redesigning the value chain, a close second is figuring out future profit pools. As food and product companies respond to demand changes, how will that disrupt the value chain, and who will be the new winners?

Teasing out scenarios can help companies uncover new business opportunities. In some cases, companies will be able to act alone to seize a competitive advantage. But since sustainability is such a large issue, some of these changes will require industrywide coordinated action. For example, organizations like the Alliance to End Plastic Waste bring together consumer product companies, chemical manufacturers, energy providers, and technology firms to work on systemic solutions to the issues of plastic waste and recycling.

It will take breakthrough, innovative thinking and a mentality geared toward innovation and experimentation to pull this off. Some of the most forward-thinking and innovative companies are up to the challenge but have a long way to go. The opportunities are out there, and the urgency to act continues to grow.



Critical Trends of the Energy and Natural Resources Transition

Time for ESG Investors and Energy and Natural Resources Companies to Work Together

Companies and investment funds are more likely to achieve their ambitious goals if they work closer together.

By Peter Parry and Joe Scalise

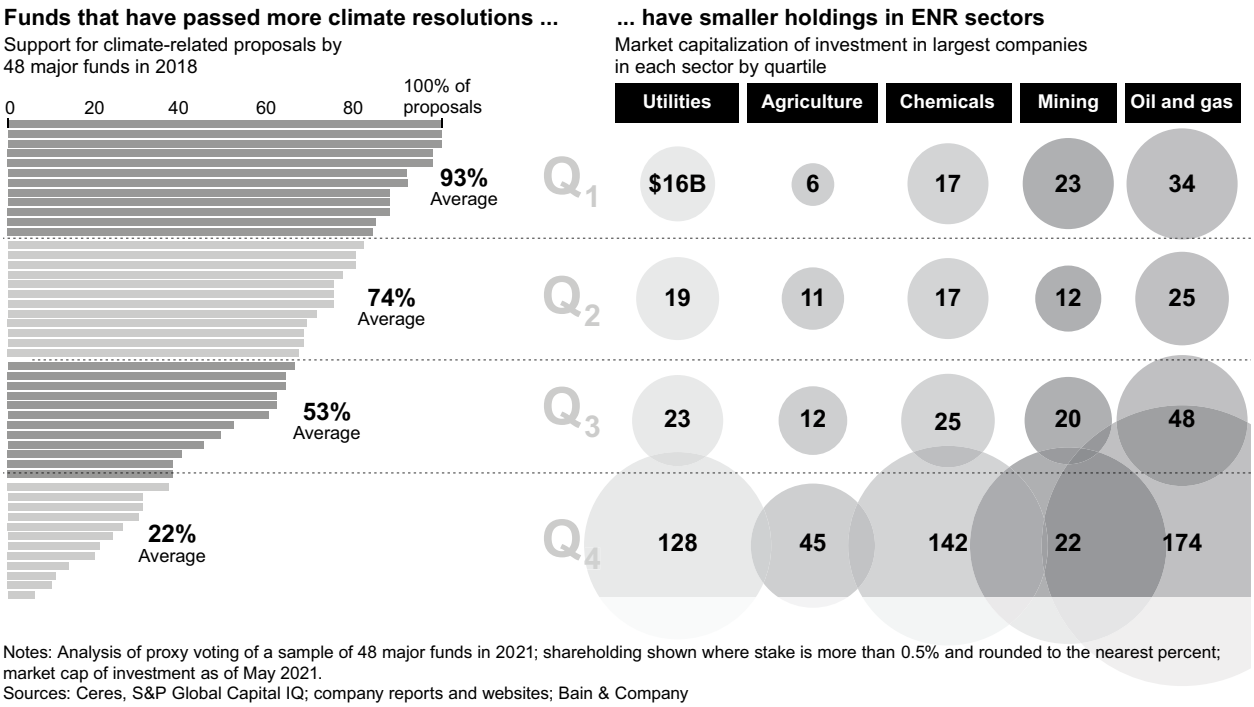
At a Glance

- More capital is flowing into funds that invest according to principles of environmental and social responsibility, and good governance. It's becoming increasingly important for energy and natural resources companies to provide investor propositions that allow them to tap those funds.
- The activism of ESG investors has helped executives grasp the scale and urgency of issues related to climate change, kick-starting the response.
- Now it may be time for ESG investors and energy and natural resources companies to work together to accomplish their common goals.
- Although these companies have the experience and capabilities to drive the energy transition at industrial scale, they'll struggle to do so if they're poorly funded.

Energy and natural resources (ENR) companies have had a bumpy ride with ESG investors over the past few years. Capital is lining up behind ESG funds, which focus on promoting principles of environmental and social responsibility, and good governance. For example, the Net Zero Asset Managers group recently highlighted 87 funds with close to $37 trillion in assets, and some investors have taken high-profile advocacy positions. Bain's analysis finds that funds with more climate resolutions tend to have smaller holdings in ENR sectors *(see Figure 1)*.

Relations between ENR companies and ESG investors have become strained, particularly on issues of carbon emissions and climate change. Shareholder pressure to set climate targets, link compensation to outcomes, and adopt resolutions at annual meetings has increased, and companies are looking for ways to manage them. Occidental Petroleum and Conoco recently asked the Securities and Exchange Commission if they could ignore these resolutions at their annual meetings since climate goals are now just a part of ordinary business operations, but the SEC denied the request and ordered them to proceed with the votes. These shareholder challenges are becoming more common not only with oil and gas majors, but across the energy and resource sectors as carbon emissions, water use, and transparency become higher profile issues.

Figure 1: Institutional investors that have approved more climate proposals hold smaller investments in energy and natural resources



Notes: Analysis of proxy voting of a sample of 48 major funds in 2021; shareholding shown where stake is more than 0.5% and rounded to the nearest percent; market cap of investment as of May 2021.
Sources: Ceres, S&P Global Capital IQ; company reports and websites; Bain & Company

However, if we think about the relationship between ESG investors and the ENR sector as progressing in waves, it may be time to declare that this first, adversarial wave has run its course. The adversarial wave has achieved a great deal. Executives have a better understanding of the scale and urgency of the challenge before us, and most have committed to greater sustainability in their operations and products. Pilot programs are well underway, but to achieve scale industrialization of these transitions, we'll need to take a different tack.

Both sides, companies and investors, must begin to realize that they're more likely to achieve their objectives through collaboration rather than confrontation. If companies want to ensure access to the capital necessary to build a net-zero world, they must be prepared to show they can scale quickly and demonstrate the economic viability of new models. For their part, investors should be prepared to "lean in" to companies that show they can reduce carbon emissions at scale and create new options for the future.

First wave: confrontation

In the wake of the 2015 Paris Agreement on climate change, ESG investors sharpened their focus on corporate and investor responsibility, adopting one or more of these strategies.

- **Activism.** Investors are pressing companies to raise their game on ESG matters through specific targets, measures, and portfolio shifts, and to adopt specific resolutions, such as linking executive compensation to outcomes.
- **Avoidance.** Investment funds are announcing policy guidelines and have divested from companies that failed to meet their expectations.
- **Articulation.** Investors are requiring companies to redouble their efforts and shift communications from low-impact vanity projects to fully formed strategic plans and roadmaps, with economic rationales.

Leading companies are beginning to make progress, setting CO_2 targets in line with the Paris Agreement and addressing relevant aspects of United Nations' Sustainable Development Goals. Others are improving the transparency of their supply chains and appointing new faces to boards to speak more forcefully for sustainability. Companies are tackling larger issues collaboratively, as in the Alliance to End Plastic Waste. While a lot of work lies ahead, the contours are beginning to emerge of a next wave that will require more cooperation.

Second wave: collaboration

With momentum established and ESG targets growing, the challenge shifts from recognizing the need to change, to funding that change sufficiently to make a difference. Energy and resource companies will need to draw on the strength of their traditional businesses to secure funding for capital expenditure in new assets and infrastructure that supports the energy transition, everything from

bio feedstock production to renewable power generation, hydrogen electrolyzers, electric vehicle charging infrastructure, waste recycling, and much more.

However, over the past decade, investors have been more attracted to other sectors, particularly technology and communications. In 2010, companies in energy, utilities, materials, and the industrial sector made up 30% of the S&P 500; by the end of 2020, their share had fallen to 16%. The top five oil and gas supermajors together have lost about $200 billion in market capitalization since 2015, compromising their ability to fund change at the scale and pace required.

Some will be able to recapture that ability by investing in promising second engines of growth in more sustainable businesses, such as the announcements by several oil and gas leaders of investments in areas like low-carbon power and carbon capture and storage. These commitments can spark a virtuous cycle that enables investors to rerate valuation multiples for longer-dated sustainable assets and put shareholder returns and market values back on an upward path. Improving the balance sheet this way ensures access to capital and the ability to reinvest in greater sustainability.

ESG investors could achieve more by investing in areas that need capital, instead of pulling back.

ESG investors can support this momentum by turning from adversary to advocate, leaning in to companies that demonstrate a good change trajectory—those showing 20% to 30% of future revenues coming from new, sustainable activities. They could achieve more by investing in areas that need capital, instead of pulling back. A poorly funded energy producer with a weak balance sheet is less capable of reducing or offsetting its carbon footprint than a well-supported, well-funded one.

In some cases, ESG investors could go further by helping public companies go fully or partially private for a spell, to speed up transitions that could be much more difficult under public ownership. Dell's 2013 deal with Silver Lake to take the company private again after 24 years on public markets allowed Dell to rapidly reorient its business. Dell went public again in 2018 and now has a market cap that tops $75 billion—a testament to the success of its bold move.

Other companies will transform themselves or spin off some of their more sustainable businesses to try to revalue their market positions and ensure better access to capital. Few have gone as far as Ørsted, which reoriented its business model from fossil fuels to wind energy in only a few years and has been rewarded with a return to profitability and a price-to-earnings ratio that reached as high as 40 in 2021. But many others are doing something similar with parts of the company. The spin-off of Siemens Energy in May 2020 combined some of the parent company's renewable and hydrogen assets into a new firm that investors could revalue based on the long-term potential of these more

sustainable business models. ENI has also said that it's considering spinning off or selling a minority stake in its retail and renewable businesses in 2022, to allow those parts of its business to be revalued based on their fast growth.

Third wave: reinforcement

Where might we be in five years?

If energy and natural resources companies and their investors are where they say they'd like to be in 2026, what will have changed to make that progress possible?

First, the relationship between these companies and their investors will have improved. Looking back from 2026, we saw a sea change in the dialogue between them, which became more constructive and cooperative. The best energy and resource companies were no longer just trying to convince shareholders and customers that they were doing the right things; they began demonstrating that they were changing their operations, adapting their products, and getting positive results in revenues and capex profiles. As their operations changed, they became more transparent, and the two-way dialogue became more innovative, reinforcing, and forward-looking. Their relationship with customers also changed, with ENR companies seen as key partners for business and responsible suppliers for consumers.

At the same time, these companies moved beyond pilot programs and began revamping their operations and supply chains at an industrial scale. They learned quickly and applied that learning rapidly in the next generation of activity. As these new businesses and methodologies matured, executives realized that they really can redefine the economics of their industries. They were no longer investing below the desired rate of return and hoping for a subsidy; they were investing at the rate and seeing attractive returns. Executives got better at measuring the things that traditional metrics like net present value overlook, things like company reputation, competitive advantage, customer advocacy, and the expansive options created by a growing, sustainable business.

As the energy and natural resources sectors got better at reducing and mitigating emissions, other aspects of the ESG agenda also moved closer to center stage: water scarcity, diversity and equity issues, corporate governance, stronger relationships with local communities. Some executives looked back nostalgically at a time when their performance was measured simply by profitability and share price. Those, of course, remain essential, but by 2026, the other elements of the ESG scorecard were also important indicators of a company's resilience and success.

If ESG investors and energy and resource companies can decide to work together to pursue their common goals, there's every reason to believe they can achieve them.

Whether this hindsight view becomes a reality depends entirely on how we engage in constructive dialogue across the chasm that now exists. The ambitious goals of 2030 and 2050 remain critical, and our position in 2026 will show whether we're on the right trajectory. ESG investors and the leaders of energy and resource companies can decide to work together to pursue their common goals, and given their long record of success, there's every reason to believe they can achieve them. The alternative would be the escalation of a dysfunctional relationship between the organizations most capable of making the energy transition a reality and the financing mechanisms that should be deployed to make that possible.

Critical Trends of the Energy and Natural Resources Transition

Business Opportunities in Low-Carbon Hydrogen

While the market for blue and green hydrogen takes shape, some companies are already climbing the experience curve.

By Aaron Denman, Søren Konnerup, Peter Meijer, and Brian Murphy

At a Glance

- The supply of blue and green hydrogen is still small, but energy, natural resources, and industrial companies are beginning to explore how customers will use hydrogen.
- Economic feasibility will vary greatly depending on the availability of low-carbon alternatives, which will affect whether regions export or import blue and green hydrogen.
- Consortia of companies are forming around the opportunity to climb the experience curve and gain early-mover advantages.

As climate change has risen to the top of the agenda for governments, investors, and companies, it's becoming clear that traditional abatement strategies won't get us to the goal of net-zero emissions, even with better energy efficiency and the introduction of vast amounts of renewable energy, biofuels, batteries, and carbon capture. Other innovations will be needed, and among the most promising is low-carbon hydrogen, which will help close the gap in industries that could prove hard to abate otherwise, including heavy-duty transportation, steel manufacturing, and production of fertilizer and methanol.

The current market for hydrogen is about 115 million metric tons, but Bain's research estimates this could increase to 300 million metric tons by 2050, with the low-carbon component growing from virtually nonexistent to most of the supply. (For more on the developing market for hydrogen, read the Bain Brief "Five Imperatives to Thrive in a Hydrogen Future.") Growth rates in green hydrogen (produced from zero-carbon sources) and blue hydrogen (produced from low-carbon sources) will outpace traditional energy markets, creating attractive opportunities along the value chain.

Hydrogen's feasibility will vary across regions and industries, and many companies are already experimenting in consortia to expand hydrogen's reach. Most are grappling with the same questions. What's the best way to participate in the burgeoning hydrogen market? What are the most attractive opportunities, where should we play in the value chain, and how do we ensure we have the right capabilities to move forward?

Identifying opportunities

Much of the attention has focused on how to supply low-carbon hydrogen at prices competitive with gray hydrogen (made from fossil fuels) or other low-carbon energy sources, but customer demand will ultimately drive the market. Leaders start by developing a clear understanding of their customer's needs, then figure out where hydrogen could make sense in filling them. This requires determining whether the cost of hydrogen can be competitive, given regional dynamics, regulatory incentives, and other low-carbon alternatives. Even when it cannot, some customers may be willing to pay more to meet their own sustainability goals.

Early projects show several different approaches, including some that are already feasible without subsidies, and others intended to develop new markets *(see Figure 1)*.

Figure 1: Hydrogen projects show a range of models; some are based on market economics and others depend on subsidies

	Market exists today for specific applications	**Market exists today,** typically with subsidies	**ESG motivation first,** competitive later	**Breaking ground,** new market to develop
Examples	**Toyota forklifts** Hydrogen fuel cells recharge faster than batteries, and perform better at low-charge levels	**Nikola Motor Company** Hydrogen refueling stations for fuel cell trucks to transport beer for AB InBev **H2 Green Steel** Iron and steel production using renewable energy to produce hydrogen	**North-C-Methanol** Integrated methanol offtake from green H_2 and captured CO_2 in industrial cluster **Ofgem and SGN** Home heating in Scotland, with significant investment from regulator and government	**thyssenkrupp** 88MW hydro-to-H_2 plant in Quebec; final offtake will require market development **Air Products, Neom, ACWA** 4GW solar/wind-to-ammonia in Neom, but final market still unclear
Where to look	Applications where hydrogen performs well and the need to decarbonize is strong (such as avoiding indoor emissions)	Geographic pockets with favorable economics (California, Arizona, the European Union)	Regions with oil, ammonia, or methanol production and aggressive net-zero ambitions (Japan, the Netherlands, Belgium)	Regions with access to cheap renewable energy but with less demand for hydrogen (Chile, Australia, the Middle East)

Note: ESG stands for environmental, social, and corporate governance
Source: Company websites and press releases

For most applications, low-carbon hydrogen isn't yet competitive with other low-carbon technologies, but there are a few exceptions, depending on location and other factors. Forklifts are one example. Because the refueling time is much faster than for a battery, and because a fuel cell's output doesn't wane at low-charge levels, forklifts powered with hydrogen fuel cells already present a competitive option with superior performance and flexibility. An electrolyzer running from grid-sourced renewable electricity can produce enough green hydrogen for a fleet of forklifts. Vehicles used in mining are another example where hydrogen could make sense as a tool for decarbonizing, given the similar uptime requirements.

Other applications make economic sense only in certain places with unique economics. To identify these opportunities, companies need to determine regional differences in the economics of hydrogen—in other words, they must "de-average" global costs. For example, at a global average, green hydrogen is about two to three times as expensive as gray hydrogen. But much of that cost difference lies between the renewable electricity used to generate green and the price of natural gas to produce gray, whose prices vary widely by region. Places endowed with rich renewable energy conditions (such as plenty of wind and sunshine) can offer far better economics for green hydrogen. In Chile, for example, few hydrogen projects are underway, but ample wind and solar could help it produce low-carbon hydrogen for less than $2 per kilogram by 2025. Understanding where below-average low-carbon hydrogen costs align with above-average alternative costs will lead to the earliest pairings of supply and demand.

In regions with excess renewable energy, hydrogen offers a low-cost way to use electricity that might otherwise be curtailed.

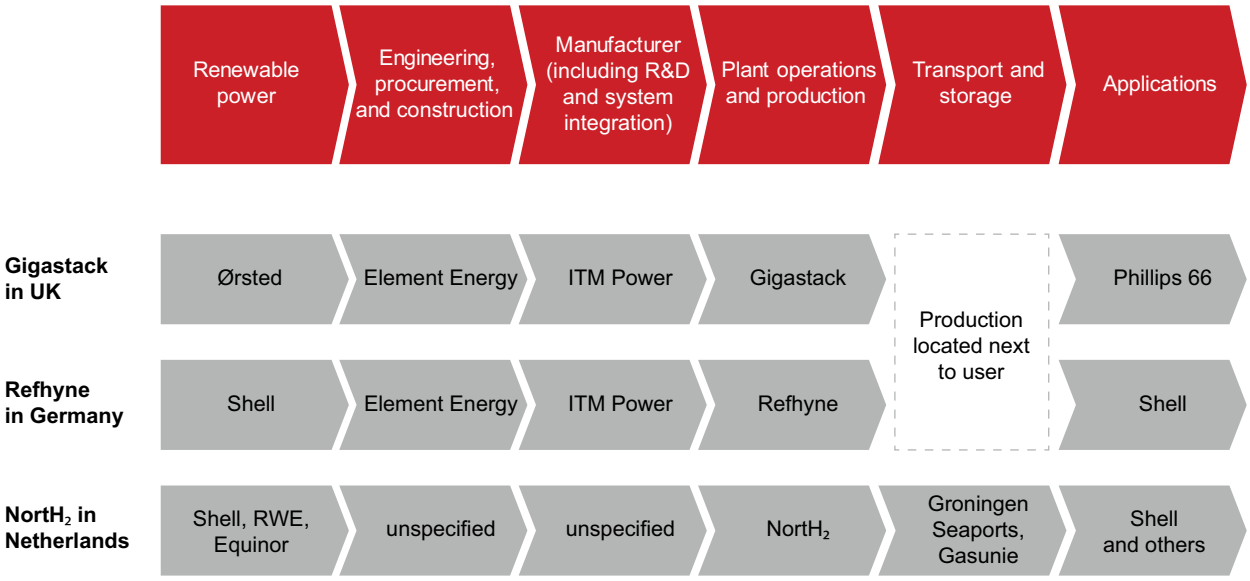
In regions with excess renewable energy, hydrogen offers a low-cost way to use electricity that might otherwise be curtailed. For example, in the sunny southwestern US, zero-emission truck maker Nikola Motor Company secured a below-market rate for solar-generated electricity ($27 per megawatt hour) to produce more competitive hydrogen, some of which will refuel trucks for Anheuser-Busch's shipping lane from Arizona to California. This agreement highlights how hydrogen can help companies meet their decarbonization commitments.

Smelting is another example of an application with long-term potential for hydrogen, but where unique economics and government subsidies enable early applications. ArcelorMittal, for example, has announced plans to retrofit two of its plants in Germany to make carbon-neutral (or green) steel. In Sweden, the steel manufacturer H2 Green Steel provides yet another example. In this case, an abundance of renewable energy and iron ore makes green hydrogen an attractive route to produce low-carbon steel.

The pipeline for announced hydrogen projects grows nearly every day. Many of these involve consortia of companies teaming up to meet demands along the value chain, from development of facilities through production of hydrogen and consumption in the making of ammonia or methanol *(see Figure 2)*. Although low-carbon hydrogen still costs more than gray hydrogen, these industrial companies are gaining experience that their competitors lack. At the North-C-Methanol project in Belgium, for example, hydrogen produced with renewable energy is consumed in methanol production along with captured CO_2, greening the process. Japan's power sector represents another set of hydrogen customers with environmental, social and corporate governance commitments, high alternative fuel costs, and limited options to decarbonize.

Projects are also underway in regions with lots of wind and solar energy but limited domestic consumption of hydrogen. Neom, an experimental city of the future under development in northwestern Saudi Arabia, is one such location. A $5 billion collaboration between Neom, Air Products & Chemicals, and Saudi Arabia's ACWA Power will produce green hydrogen with electricity generated by solar in the day and wind at night, to gain experience, develop the market, and scale production as demand rises to meet it. In the near term, this systems approach will produce hydrogen for use locally in Neom, with the long-term goal of scaling to support exports. Australian production follows a similar model and is the global leader in announced green hydrogen projects *(see Figure 3)*.

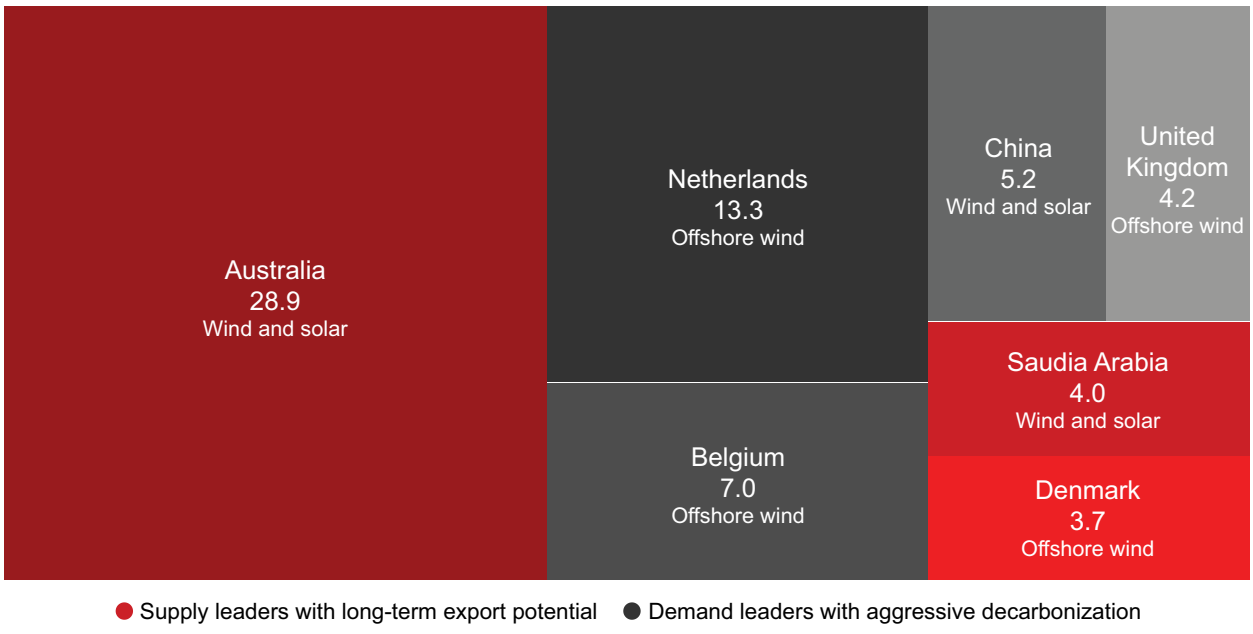
Figure 2: Companies are collaborating in consortia across the value chain



Sources: Market participant interviews; news articles; company websites; Bain & Company analysis

Figure 3: The seven countries with the greatest green hydrogen capacity vary in their likely long-term roles

Electrolyzer capacity (GW) and main sources for announced projects



Sources: International Energy Agency Hydrogen Projects Database; news articles; Bain & Company analysis

Finding your place in the value chain

The market for low-carbon hydrogen is new and likely to remain in flux for a while. As players consolidate their views and experiment with business models, many are struggling to get started and find their focus. The most effective way to avoid dead-end experiments and to gain a leading position is to develop a clear view of the value chain, potential profit pools, and what it takes to win in these future profit pools.

As in any new market, companies should assess which current capabilities might give them a competitive edge in hydrogen *(see Figure 4)*. A European manufacturer in the renewable energy space considered its strengths in engineering, procurement, and construction (EPC); electrical systems; power controls; and system integration. Geographically, it has a strong presence in several locations with potentially high demand. Executives decided that it could use these capabilities to design power-generating assets and production sites for low-cost hydrogen and help scale production in the electrolysis industry.

Figure 4: Different sectors have varied advantages in building an edge in the hydrogen economy

Utilities	• Natural extension of business in building and owning assets • Strong capabilities in renewable energy development, as well as engineering, procurement, and construction (EPC) • Existing relationships across the value chain, including offtakers (refiners, chemicals, fertilizers, aluminium, steel)
Oil and gas	• Potential green hydrogen customers • Gas capabilities and emerging renewable energy capabilities make hydrogen a logical choice for a second growth engine • Substantial development experience
Industrial gas	• Core competencies in production and handling of industrial gases • Familiarity with customers in long-term industrial demand segments
Renewable energy original equipment manufacturers	• Experience with renewable energy generation, hydrogen production, and system integration with electrolyzer • Existing global scale, footprint and relationships in EPC, as well as service • Identification of high-potential green energy production locations
Electrolyzers	• Key technical enabler for green hydrogen • Supply shortage expected in the short to medium term could provide leverage
Offtakers (Refining, fertilizers, chemicals, aluminium, steel)	• Ability to drive early demand for existing production facilities • Some familiarity with gray production should help transition to blue • Industry knowledge needed to integrate hydrogen into existing production

Note: Select examples, not exhaustive
Source: Bain & Company

Closing capability gaps

In the emerging hydrogen project consortia, companies are combining their strengths to complete the value chain. In many cases, oil and gas majors or utilities are taking on the role of project developer, with the output often used within refining, ammonia production, or blending into existing natural gas networks. Securing such offtake partnerships is critical for these early consortia, because a significant merchant market isn't expected to develop before 2030. In the current project pipeline, some oil and gas companies are taking both the project developer and offtake roles.

Over time, the value chain is likely to consolidate as companies integrate forward or backward. For example, manufacturing and EPC companies in oil and gas or renewable energy could extend their core capabilities into optimizing electrolyzer production, taking out weight, applying a modular approach, and procuring components at lower cost. At the same time, these companies may need to close gaps in stack and electrolysis design, where there are many partnerships with electrolysis pure players.

New partnerships will be essential. Consider a renewable energy original equipment manufacturer (OEM) seeking a larger role in the value chain, which might include electrolysis design and access to end customers. It would make sense to seek out an electrolysis partner to combine capabilities to design and scale production. To cover its gaps in the gas and end-consumer markets, it could partner with strong midstream and downstream partners, such as oil and gas majors. That would help the OEM focus on taking market share and developing repeatable models that will enable it to expand to other geographies.

Moving forward to execute

The hydrogen market is moving quickly. A year ago, most executives were just beginning to consider where hydrogen would play a role in their industry's value chain. Today, companies have started deploying strategies for using hydrogen, all while maintaining the flexibility to adjust as the market evolves and conditions change.

Winners in this market will be companies that can develop a keen understanding of hydrogen's potential and economic feasibility, as well as a determination of their place on the value chain. Setting long-term strategic goals will be essential, with progress measured against short-term milestones.

Finally, no new program will gain much traction without strong support from senior management. Some companies will invest in hydrogen as a second engine of growth (see "Engine 2: How to Grow a Sustainable New Business"). Only by guaranteeing continued support, and securing the resources to make it happen, can companies ensure that their investments in hydrogen will have a chance to succeed in the developing energy economy.

Strategic Advantages for Addressing the Transition

Strategic Advantages for Addressing the Transition

Raising Productivity in Energy and Natural Resources Capital Projects

Agile and lean methodologies raise capital efficiency in engineering, procurement, and construction.

By Alistair Corbett, Emily Emmett, Felipe Gattass, and Brian Murphy

At a Glance

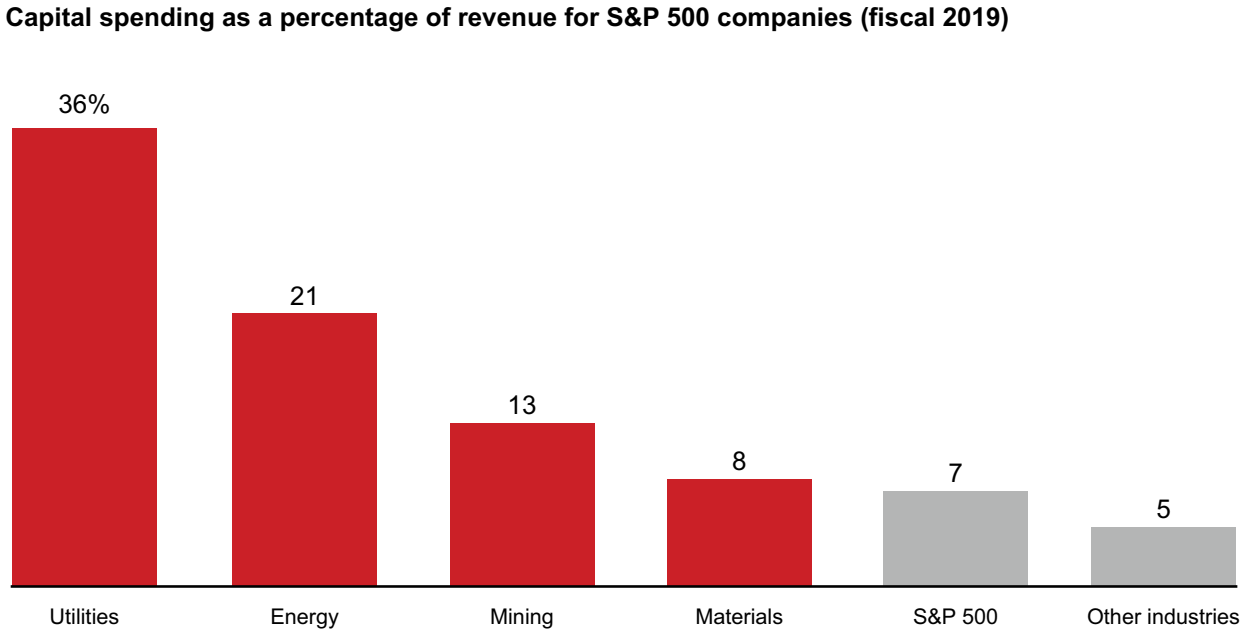
- Large construction projects frequently run over budget and beyond schedule. That's got to change. To pay for the energy transition, companies need to spend capital more efficiently.
- Deploying cross-functional teams and Agile methodologies in the engineering phase of projects can save time and money.
- More transparent procurement processes, with cost benchmarks, can increase the efficiency of money going to suppliers.
- Better cooperation between construction contractors and managers can improve efficiency in construction; one mining company recovered 12 months of lost time and saved over $500 million on a major project.

No sector spends more of its revenues on capital expenses than the companies in energy and natural resources *(see Figure 1)*. They'll have to spend much more as they retrofit old assets and build new ones that meet increasingly strict sustainability requirements, those imposed on them by regulators and the goals they set themselves. Estimated spending on infrastructure to meet the needs of a decarbonizing economy range as high as $50 trillion over the next three decades.

Some of these capital projects represent new opportunities where incumbents lack experience—for example, in hydrogen, renewables, carbon capture and storage, and rare earth materials. These will carry new risks, and that will make it even more challenging for these companies to properly allocate capital to these investments.

No sector spends more of its revenues on capital expenses than the companies in energy and natural resources.

Figure 1: Energy and natural resources industries spend a greater share of revenues on capex than other industries



Sources: S&P Capital IQ; Bain & Company

But capital projects across the sector are already notorious for delays and cost overruns *(see Figure 2)*. Bain's analysis of 76 large energy and natural resources projects around the world found that 34% of them incurred cost overruns, which averaged about 17%, and 84% faced delays, which averaged more than two years. Those that do finish on time often have budgets that allow for low productivity and high costs. Many of these are megaprojects in oil and gas, utilities, chemicals, and mining, netting out in the billions and tens of billions of dollars. The vast scale of these projects, their complexity, and the long timelines all contribute to the many delays and overruns. As the development requirements become more stringent to meet environmental and community demands, these projects will become even more expensive and complex. For example, some mines are using ocean water so that their operations don't drain the fresh groundwater supply. But using ocean water—transporting and desalinating it—can add 15% to 30% to a multibillion-dollar mining project. Implementing carbon-capture or emissions-reduction technologies on industrial plants also increase the costs.

These companies really need to develop and build new capital projects more efficiently if they want to remain leaders. Oil and gas companies, utilities, and chemicals and mining firms will compete for capital and other resources as they seek out first-mover advantages, trying to position themselves higher on the learning curve than competitors that take a wait-and-see attitude. Slow movers may find themselves saddled with stranded assets and businesses in decline if they can't adapt to new demands. Given all that's at stake, capital efficiency advantages of even 10% to 20% or shorter schedules to get projects to market could have existential implications.

Figure 2: Many energy projects encounter delays and go over budget, leaving significant money on the table

Of 76 major projects in operation from 2015 to 2019 ...

Note: Includes projects developed by large public and private engineering and procurement firms, large oil-refining companies, and large natural gas and oilfield equipment companies
Sources: IHS Markit; Bain analysis

To try to capture those gains, companies are redesigning their models for engineering, procurement, and construction. One of the most important steps is adopting an Agile methodology with a lean mindset shared by the project team, the engineering contractor, the sponsor, and the client. In procurement, better analysis of costs and greater transparency are helping to rein in costs. And in construction, closer cooperation among the construction contractors and construction managers, coupled with a "red is good" mentality—that is, a willingness to deal with problems rather than ignore them—can improve capital efficiency. Companies that are executing well on these three dimensions are reducing capex by 15% to 30% and shortening construction schedules by 6 to 18 months.

More Agile engineering

For a long time, the engineering phase of capital projects has been trapped in a single way of working that results in long development times and frequent rework. Firms usually outsource the design task to the engineering firm with the lowest bid and limit their own involvement to reviews at key stages. This waterfall method works well for slow-moving, simple projects. But it falls short against the demands of frequently changing projects in a competitive environment.

Some energy and resource companies are beginning to deploy Agile methodologies to shorten the engineering cycle and expand the owner's role from a reviewer to a more active participant. Agile speeds up the cycle by bringing cross-functional teams together, with experts from the areas that should have a voice in the design, including construction, sustainability, planning, and control.

One global mining company experimenting with Agile found that it helped cut the basic engineering cycle of a project in half while reducing staff hours by 40%. The active involvement from other related functions resulted in a simpler and more capital-efficient design. Scaling the methodology across the entire engineering team will require a big transformation, with changes to the operating model and procurement processes.

Another company used Agile teams to improve the design of a conveyor belt system for carrying materials out of a mine, cutting 15% off the cost. Among the innovations that a cross-functional team contributed: instead of lining the belt's corridor with a series of individual lamps, each requiring its own wiring and maintenance, the design used two rows of LED lighting tape, which was quicker to install, less expensive to maintain, and distributed light more evenly throughout the corridor. Others are using Agile in early stages like concept definition and contractor selection, shortening the time to evaluate trade-offs and learning how to determine the minimum amount of information necessary to make good decisions.

Of course, in the mission-critical designs that make up most projects in the sector, Agile methodology can't mean abandoning good governance. But companies experimenting with Agile are finding that it works well within the bounds of a traditional stage-gate process.

More transparent procurement

Traditional procurement entails bidding on unit-cost or lump-sum contracts to get the best rate at the lowest risk. But these contracts carry a fair amount of uncertainty and risk, so construction companies usually build a cushion into their bids by padding the price of labor, materials, or other general costs, or by stretching the schedule.

These risk-adjusted prices then become the baseline for the contract's management, and both the contractor and the construction manager will direct the project according to these inefficient targets. Inevitably, unforeseen costs arise, and these get added on top of the already inefficient base. Organizations wind up running on contracts based on unknown risks, lax yields, and long schedules.

A better way to manage procurement is to analyze contract costs based on benchmarks and reviews. A cross-functional team, with people from engineering, procurement, construction, and supply, should lead negotiations with contractors. Negotiations should be transparent and technical, structured in ways that ensure the contractors understand the scope and context of the project, and include open discussions on construction methodologies, yields, and staffing requirements. When owners also take on the risks that the contractor can't manage—such as interference from other contractors or with operations—they can manage these conflicts better, reducing costs and making construction more efficient.

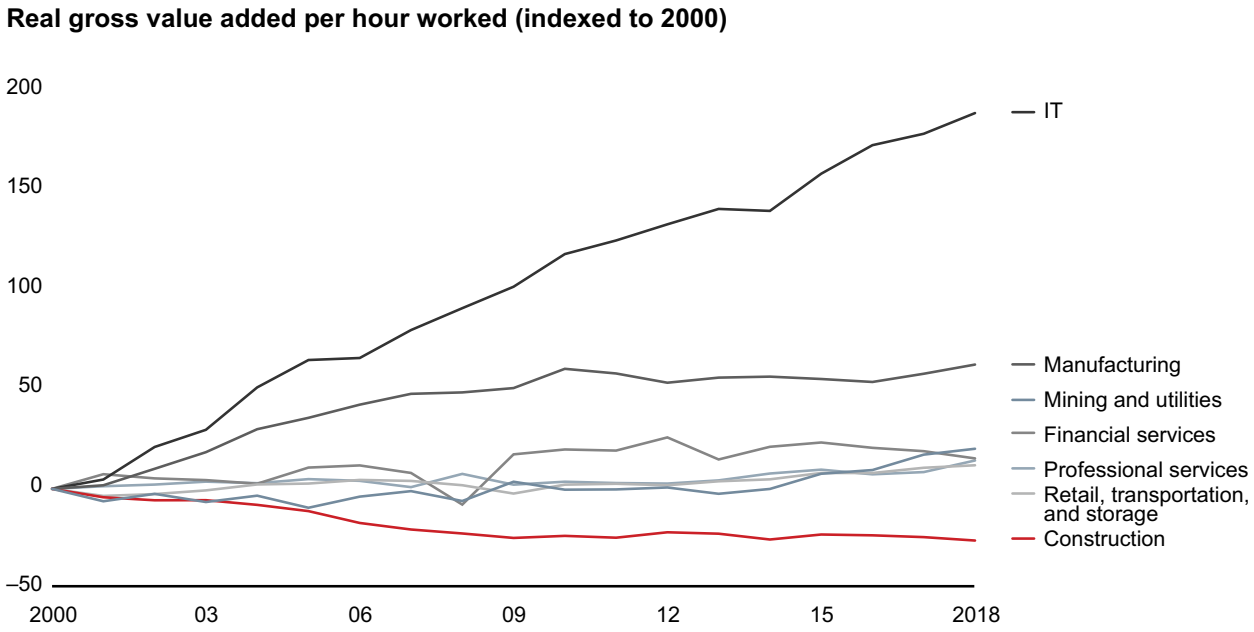
Construction: Red is good

Engineering and procurement both set the stage for the most difficult phase of any project, construction. While other sectors have significantly raised productivity over the past two decades, construction is an outlier *(see Figure 3)*.

One reason is that construction has been among the slowest sectors to embrace digital technologies—though that's beginning to change. Building information modeling (BIM), advanced work packaging (AWP), and connected worker solutions are among the initiatives that construction companies and their customers are deploying to make their capital projects more efficient. But companies also need to find better ways to work with their contractors to boost productivity and shorten construction schedules.

One way they can do this is through joint reviews of the construction schedule, examining the sequence, construction methodology, and productivity yields. They set the target by building a schedule based on ideal conditions, then work to meet those milestones. To make daily progress on this full-potential schedule, they follow daily routines, hold weekly *obeya* meetings (war room sessions to review progress, causes of noncompliance, and the next week's plan), and employ other continuous improvement techniques borrowed from lean manufacturing. Contractors and construction managers meet weekly to discuss progress on the sequence and yields, and how to clear barriers that are hurting productivity.

Figure 3: Construction is the rare sector whose productivity has declined since 2000



Sources: OECD; Shaping the Future of Construction, WEF

Of course, all this is easier said than done. Accomplishing it requires a shift in mindset among the leaders of the construction contractor and construction management teams, and their sponsorship must be reinforced and transparent to everyone on the team. Leaders adopt a "red is good" mentality: workers who flag something that is off track or falling short are praised rather than punished, because it allows the project leaders to identify problems and opportunities for improvement. One mining company that adopted these construction management techniques recovered about 12 months of lost time, saving more than $500 million and putting the project back on track to finish ahead of schedule.

These dramatic increases in productivity and efficiency are the kinds of change that energy and natural resources companies should aspire to if they want to lead the transition to a more sustainable, low-carbon economy. The record is mixed, and this path requires openness to new ways of working and a collaborative mindset. But the opportunity is huge, and the path forward is clear and achievable.

Strategic Advantages for Addressing the Transition

Creating Resilience, Sustainability, and Accountability in Supply Chains

Price and quality are still important, but now companies have more to consider.

By Peter Guarraia and Stephan Zech

At a Glance

- Supply chain goals are now about more than price, quality, and inventory levels.
- Shortages during the Covid-19 pandemic underscored the importance of building resilience into supply chains.
- As consumers and shareholders demand greater accountability and sustainability in their products, supply chains are also becoming more transparent and traceable.
- New digital tools are helping companies reduce waste, improve accountability, and increase worker safety.

For most of their careers, supply chain and operations managers have had a clear mandate: source materials and deliver products at the right levels of quality, for the best available price. In energy and natural resources, that has meant delivering crude oil, natural gas or refined products, chemicals and plastics, mined materials, and agricultural products, all at the right levels of quality and at prices customers will pay.

Suddenly, that formula has become much more complicated. Quality and price remain table stakes. But operations are now measured on a broader scorecard, which can include greenhouse gas emissions and other measures of sustainability, resilience to supply and operations disruption, and accountability for the social impacts of their business.

Consider the events of just the past year or so. In oil and gas, demand dropped suddenly in the spring of 2020, leaving producers with a glut so large that West Texas Intermediate crude dipped into negative pricing for a day. In agriculture, as lockdowns kept consumers at home, product demand shifted away from food prepared and packaged for out-of-home dining to a new emphasis on products consumed at home. Agricultural companies had to continue to supply the world's markets while retooling packaging operations and coping with a workforce affected by the virus.

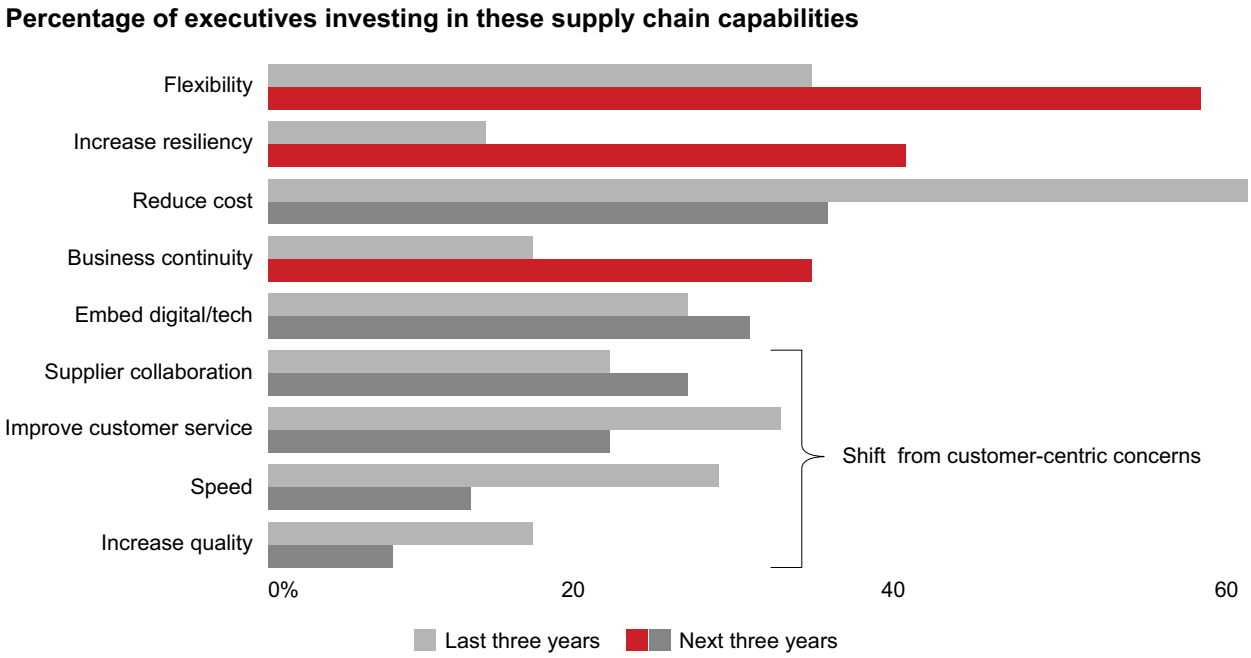
These sudden shifts came at almost the same moment that customers, shareholders, and governments were demanding more accountability for carbon emissions, plastic production, and other externalities, not only in a company's own operations, but for its upstream supply chains and downstream customers.

Supply chain and operations teams must develop new capabilities—and quickly.

All this means that the days of business as usual are over. Supply chain and operations teams must develop new capabilities—and quickly. Playing to a more balanced scorecard will require a lot of changes: reducing the carbon footprint, building greater resilience in the supply chain, creating more transparency, and ensuring accountability.

The pandemic sped up this change, and by mid-2020, supply chain executives were already reprioritizing their investments. Bain's survey of operations executives found that their investments would focus less on cost reduction and speed, and more on resilience and flexibility *(see Figure 1)*.

Figure 1: In 2020, companies shifted supply chain investments toward resilience and flexibility, and away from reducing costs



Source: Bain & Company and Digital Supply Chain Institute survey, 2020 (n=200)

New digital capabilities

The good news is that by building up the new muscles necessary to thrive in a period of greater scrutiny and more intense competition, companies can turn their operations into a true competitive weapon. An operating model that can balance efficiency with sustainability, transparency, accountability, and resilience is a model that can differentiate a company in its marketplace.

Legacy enterprise management tools, while still essential, cannot meet all the needs of a rapidly evolving operations unit. Increasingly, companies will need to adopt and develop the next generation of digital tools that focus on very specific problems, such as transparency and accountability in a supply chain, network optimization, and inventory optimization. Bain research finds that 85% of the companies surveyed said they're investing in big data and analytics. These tools have already proven themselves: advanced analytics can improve supply chain forecast accuracy by up to 60%. The next wave of capability building needs to close the loop, ensuring that the insights gleaned from analytics are put to work in operations to generate value.

An updated digital operating model

Applying digital technology to these four trends makes a big difference, not only for cost, but also in meeting other objectives of the balanced scorecard.

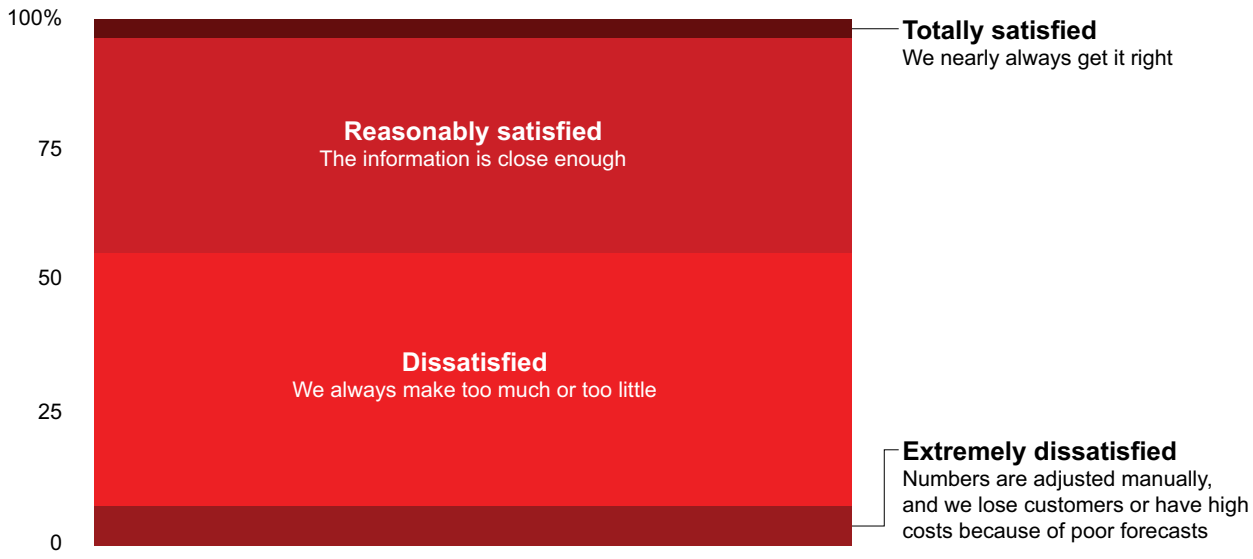
- **Smart automation.** The first waves of industrial automation addressed large, repetitive tasks, usually in controlled, manufacturing environments. A new wave of smart automation employs artificial intelligence and Internet of Things systems to manage difficult, dangerous, or precise tasks more flexibly. The shift promises to enable much more automation in energy and natural resources industries, which are often in more open and variable environments.

  For example, one technique to efficiently mine potash has required a human observer to direct a boring machine at the most promising veins of salts among dirt and rock, deep underground. Smart automation puts sensors and intelligence on the process, making the same or better decisions about where to aim the borer—improving yields, reducing waste, and keeping the operator in a safer location. Drone monitoring is also promising. For example, utilities that rely on coal fuel can deploy drones to survey their stock of coal, make 3-D models, calculate the remaining supply, and report on the condition (dry or wet) of the coal.

- **End-to-end visibility.** Companies are integrating their data sets, because that gives them a more comprehensive view of inventory levels and availability across the supply chain. But today, transparency is about more than just inventory. It helps companies see where products and components come from, and that helps them live up to their environmental and social commitments. Olam International, a commodity food company based in Singapore, developed the digital platform AtSource that traces food back through the supply chain, across processors, suppliers, and farmers. The platform provides a digital dashboard that also provides copious economic and contextual information gathered from the field, including premiums paid to farmers, emissions, land and water use, and social conditions of worker families.

- **Intelligent supply chain.** Bain research found that more than half of executives in the energy and natural resources sector surveyed said they weren't satisfied with the accuracy of their demand forecasting *(see Figure 2)*. Advanced forecasting and more sophisticated demand models promote accurate planning, which can reduce waste, not only improving the return on investment, but also reducing the footprint of supply chain operations. In the Permian Basin, for example, one oilfield service company employs remote monitoring and algorithmic forecasting to know when a well needs more drilling fluid. This reduces waste by eliminating the need for the company or its customers to send out trucks on broad "milk runs" to check on drilling fluid.

Figure 2: More than half of executives in energy and natural resources say they aren't satisfied with the accuracy of their demand forecasts



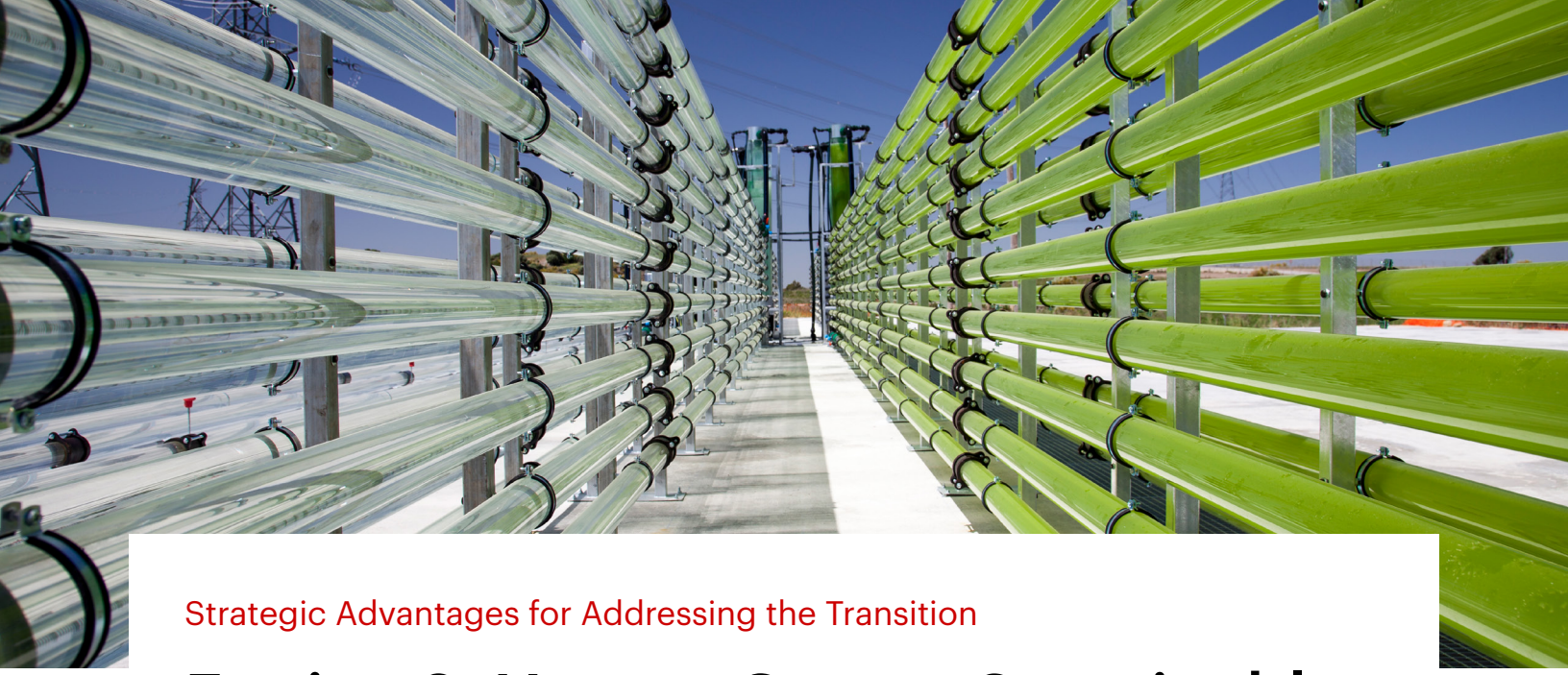
Source: Bain & Company and Digital Supply Chain Institute survey, 2020 (n=27)

Predictive planning can go much further, aggregating all the relevant data from a range of sources, including inventory levels and consumption levels, constraints in the production process, and external factors that can affect demand—everything from business cycles to the weather. Intelligent systems can generate future scenarios based on observed patterns and real-time data and come up with probability scenarios and their effects on the supply chain.

- **Next-generation talent.** As in other industries, frontline workers in energy and natural resources are becoming more technically savvy, by necessity. As the systems they depend on become more sophisticated, workers are being retrained to understand and work with the digital systems that increasingly monitor and guide their activities.

  Technology is also supporting workers in their tasks and increasing their safety. Assisted-reality (AR) headsets are moving from experimental stages to scale deployment, putting visual guidance for an unlimited range of tasks literally at workers' fingertips. One North American maritime contractor that was having difficulty finding enough skilled welders developed a system that combined artificial intelligence with AR, projecting instructions on a head-mounted display that guided welders through each task.

Finally, because operations are increasingly measured against a broader set of requirements, executives need to reexamine their capital investment plans, asking, "What am I getting for this investment, beyond cost savings?" Capital investments also need to deliver efficiency, sustainability, resilience, and agility. (For a detailed look at capital investments, see "Raising Productivity in Energy and Natural Resources Capital Projects.") If a company's capital investment decisions are still based only on reducing costs, its investment thesis is failing to keep up with its strategic ambitions.



Strategic Advantages for Addressing the Transition

Engine 2: How to Grow a Sustainable New Business

As pressure builds on energy and natural resources companies to change their businesses, they can tap their existing assets and skills to develop new ones.

By Sasha Duchnowski, Aleksander Lyngvi, and Brian Murphy

At a Glance

- The energy transition and the shift to a low-carbon economy are disrupting industries, but also creating new opportunities.
- Energy and natural resources companies must develop a second engine of growth, an "Engine 2" that combines the assets of the core business with entrepreneurial energy.
- Engine 2 also signals to investors and new talent that the company is looking forward and developing new businesses that can thrive through the energy transition.
- Successful Engine 2s focus on the customer's evolving needs and adopt an insurgent mentality, which allows them to compete against new competition.

Executives in some energy and natural resources (ENR) companies are looking out 5 or 10 years and wondering: Will my core business still be viable?

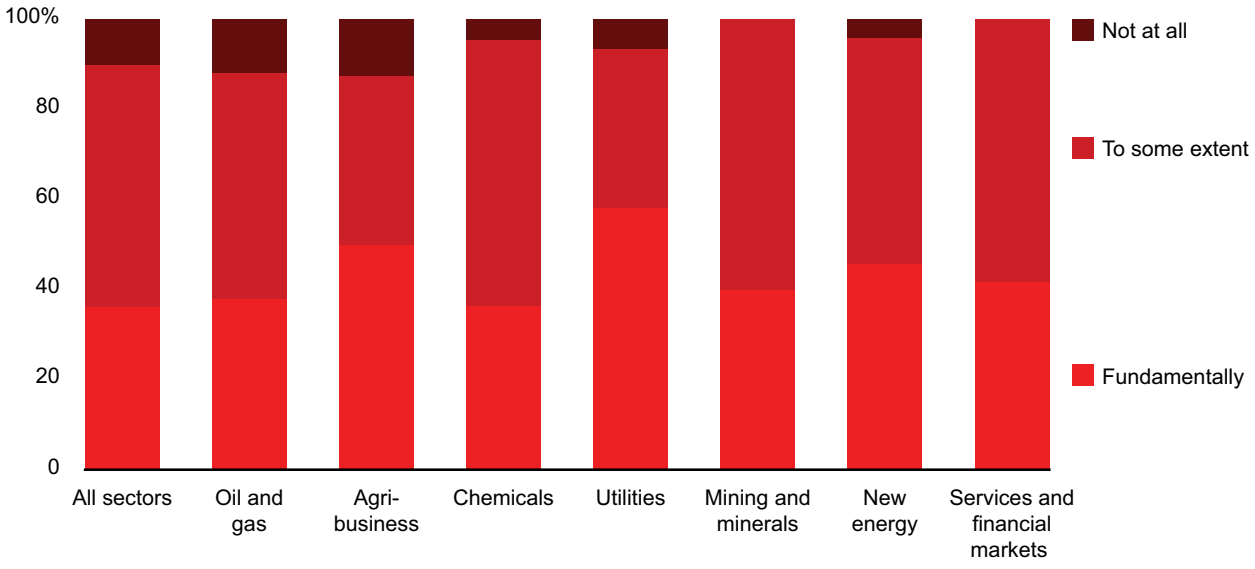
It's a reasonable question when the dynamics of sustainability and technology—low-carbon energy, electrification, and circular economics, for example—are disrupting industries that have been running on the same business model for years *(see Figure 1)*.

At the same time, they're also creating new opportunities in related businesses, and this is where many of those executives already realize they need to focus. The technical, operational, and management capabilities that serve these companies well today are going to help them move into adjacent businesses like carbon capture and storage, green hydrogen, electrification and batteries, new minerals, energy as a service, sustainable packaging, and high-margin sustainable food.

We call this Engine 2, the development of a second source of growth within the company that draws on the assets and capabilities of the core business, applying them in new ways. A successful Engine 2 taps the entrepreneurial energy of a start-up while taking advantage of the full benefits of scale of the entire organization.

Figure 1: Most executives say the energy and resource transition will change their company's core business

Percentage of executives who say the transitions will affect their business to this extent, by sector



Source: Bain ENR Transition Survey, October 2020 (n=69)

In the energy and natural resources sector, two forces are coming together to create new growth opportunities: the demand for sustainability, and the new technologies that are making more sustainable businesses possible. While many of these technologies like solar and wind have been around for a while, they've only recently reached levels of maturity that make them cost effective and competitive with older technology. That's opening the door for businesses that are as focused on the bottom line as on their sustainability goals.

In today's environment of intense scrutiny, the benefits of an Engine 2 that emphasizes sustainability go beyond revenue generation. Engine 2 ventures can be an important signal to investors that leadership is keenly aware of pressures on the existing business and has its eye on the profit pools of the future. Although the initial revenues from Engine 2 will be small, they can boost confidence in the company's future, making investment more attractive. Engine 2 efforts are also vital in attracting top talent, particularly in industries that are often considered slow to move or resistant to new technology.

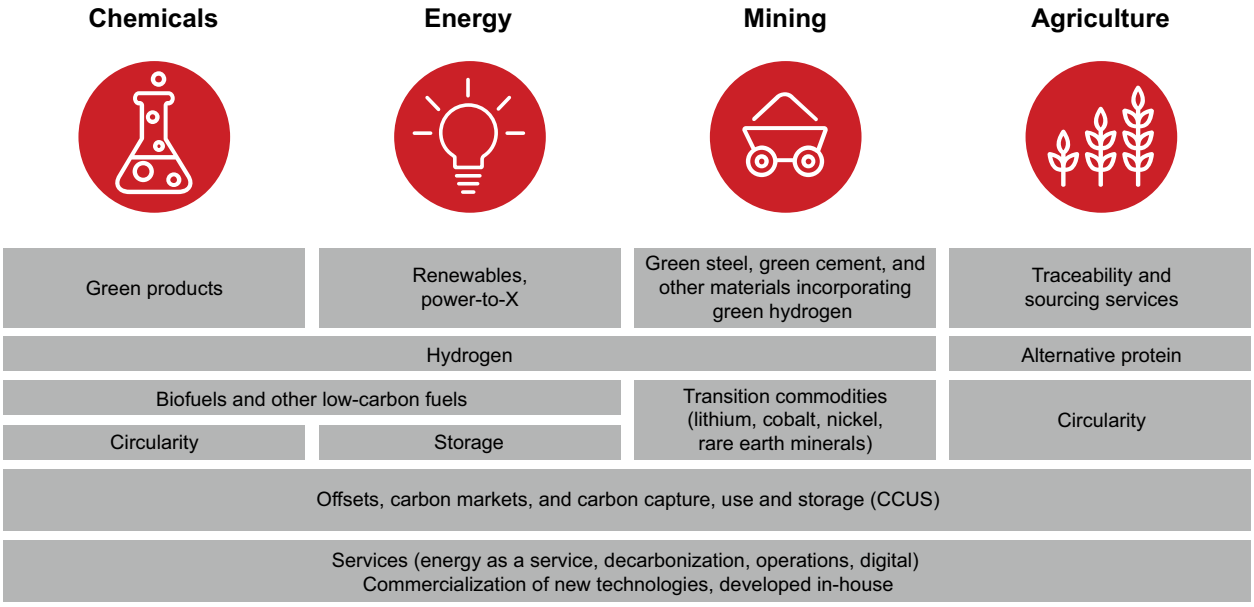
What to look for in an Engine 2

How should companies decide where to place bets that allow them to stand out from the crowd? Bain's research has identified four factors common to successful Engine 2s.

- **Rapidly growing profit pools, fueled by big trends.** These future-fit profit pools include zero-carbon energy, carbon markets, green steel, sustainable fuels, high-margin sustainable food products, specialty chemicals, and commodities for batteries, like lithium, nickel, and cobalt.
- **New levers of competitive advantage, often because technology has blurred business boundaries.** In energy, for example, upstream companies are starting to compete with renewable energy pure-plays, traditional utilities, storage providers, carbon offset providers, and start-ups.
- **Capabilities or skills from Engine 1 that power Engine 2.** These could be resource access, project development or integration skills, technology, customers, partners, or access to capital, which all can provide advantages to Engine 2.
- **An entrepreneurial spirit inside the company.** This may not come naturally to incumbents that have grown by developing resources with capex-intense, large assets. But it's essential to nurture because one of the main reasons for Engine 2 failures is that incumbents underestimate the competitors that are already in the market. Remember, your Engine 2 is someone else's Engine 1.

Across energy and natural resources sectors, the same underlying triggers (sustainability and technology) are feeding these conditions for Engine 2 growth. As a result, many players within each industry are looking at the same list of Engine 2 themes *(see Figure 2)*.

Figure 2: Energy and natural resources companies are pursuing a common set of Engine 2 opportunities



Notes: Power-to-X refers to uses for the excess electricity from renewable sources that might otherwise have to be curtailed; green hydrogen is made with electricity from low-carbon, renewable sources; circularity includes designing products and packaging to reduce waste and promote recycling and more efficient reuse of resources
Source: Bain & Company

But if most players are looking at similar options, how do you avoid *your* Engine 2 becoming just another Engine 2? The real secret sauce for Engine 2 success is the "how."

How to do Engine 2

Treat the customer as the battleground. Many energy and resources businesses will have treated the resource, the cost curve, the asset, the underground reservoir, or the infrastructure as the Engine 1 battleground. Even for commodity business, the battleground in Engine 2 is much more the customer. Customers' businesses are changing, and that creates the Engine 2 opportunities to frame new solutions based on needs that customers may not yet have fully articulated. Engine 2s will demand more attention across the full R&D, product development, sales, marketing and customer service life cycle. For example, a specialty chemicals company worked closely with a select group of customers to understand the full potential of a new biodegradable polymer in specialist packaging applications. It chose the customers not only for their willingness to explore the potential of the new material, but also because they were likely to become vocal advocates for the new material once they understood its value.

Invest as if building a new business. The business case needs to be strong to invest in Engine 2, but no one should expect the economics to pay off like Engine 1—at least not at first. Not unlike venture capital, investment needs to meet the long-term goals of the company rather than the short-term needs of an investor market.

New endeavors are less likely to be a single big investment, like a billion-dollar plant or new product development. They're more likely to involve smaller and sequenced investments, triggered by testing and learning with customers—just like in a start-up. Because many Engine 2 opportunities are new businesses, it's not certain how the profit pools will develop, so companies need to keep their options open.

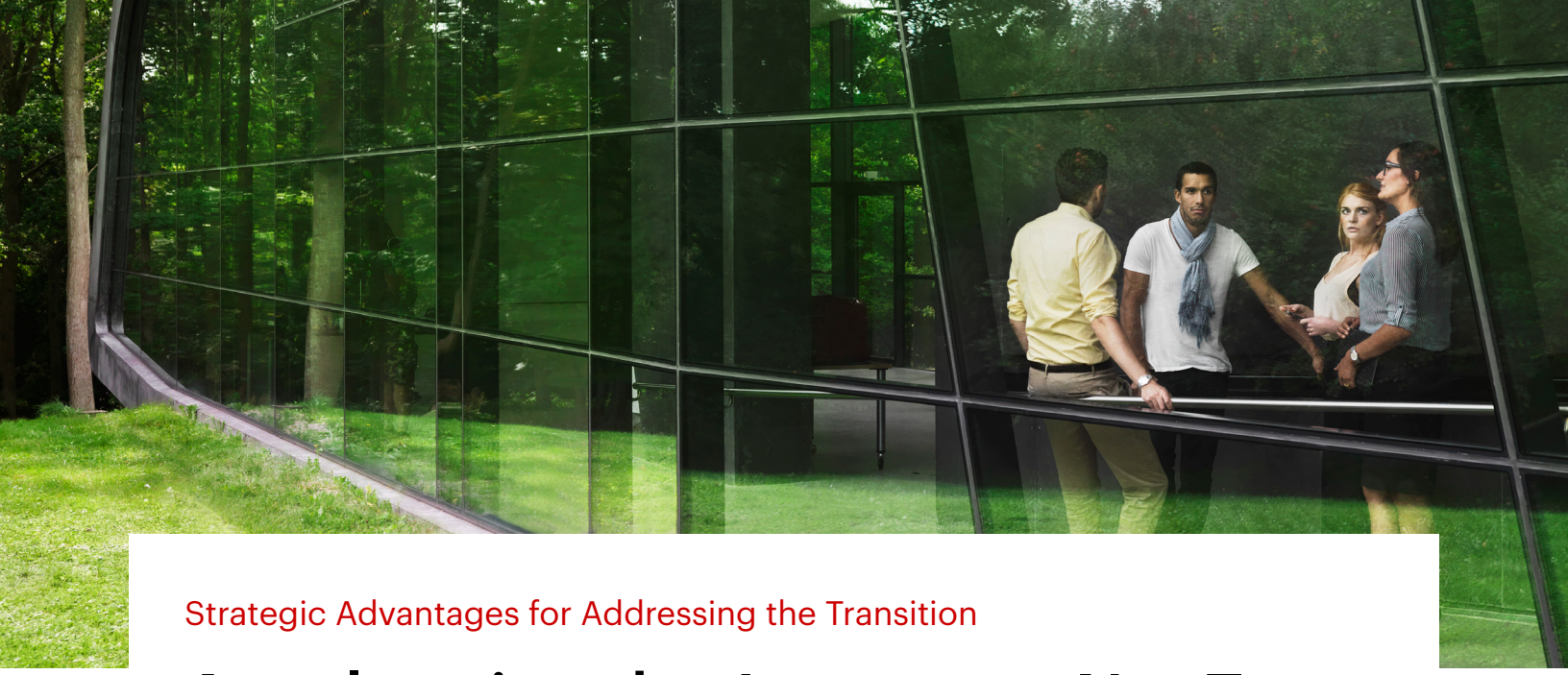
In fact, because Engine 2 options often involve unfamiliar experience curves (green hydrogen operates, for example, on different experience curves to traditional energy experience curves), speed of investment *really* matters to secure early-mover advantage with customers. It will take time to move down the experience curves, connect demand and supply, and develop the markets.

As with any new business, making the best use of partnerships for customers, capabilities, and capital is key. Sometimes the right first move isn't as the owner but as a minority interest in something with existing momentum. Hedging this way can also be an important signal of continuity to investors who remain committed to Engine 1 revenues and business models.

Adopt an insurgent growth model. Managing an Engine 2 within a large business requires a nuanced balance to take advantage of the parent's capability, while moving with the speed and energy of an insurgent. The growth model is closer to building a new venture than expanding the core business, with a fair amount of test-and-learn on the go. In this type of pursuit, it's usually better to get started on something than to wait for the perfect plan. After all, your competitors are already on the move.

ENR companies, particularly those with an engineering heritage, may struggle with this. They built their success on engineering projects to perfection, including capex and risk-heavy assets that fueled growth for decades. That model won't work as well in an environment where they're competing against start-ups, and outcomes are less certain. But every organization has people who can make this leap, bringing some of the mature organization's DNA into the fray for the next-generation marketplace.

The energy transition and the shift to a lower-carbon economy present natural opportunities for Engine 2s among today's ENR incumbents—and the field is likely to crowd around the most promising contenders. Moving assertively and treating Engine 2 like a new venture rather than simply a new product or technology will help leaders launch new growth opportunities best suited to their capabilities and market position. Approaching the opportunity with a customer orientation and an insurgent mindset will be key to gaining and maintaining a competitive edge in Engine 2.



Strategic Advantages for Addressing the Transition

Accelerating the Journey to Net Zero

Most large companies are announcing ambitious decarbonization goals. Setting a realistic path makes them more credible.

By Martha Eggenberger and Nitesh Prakash

At a Glance

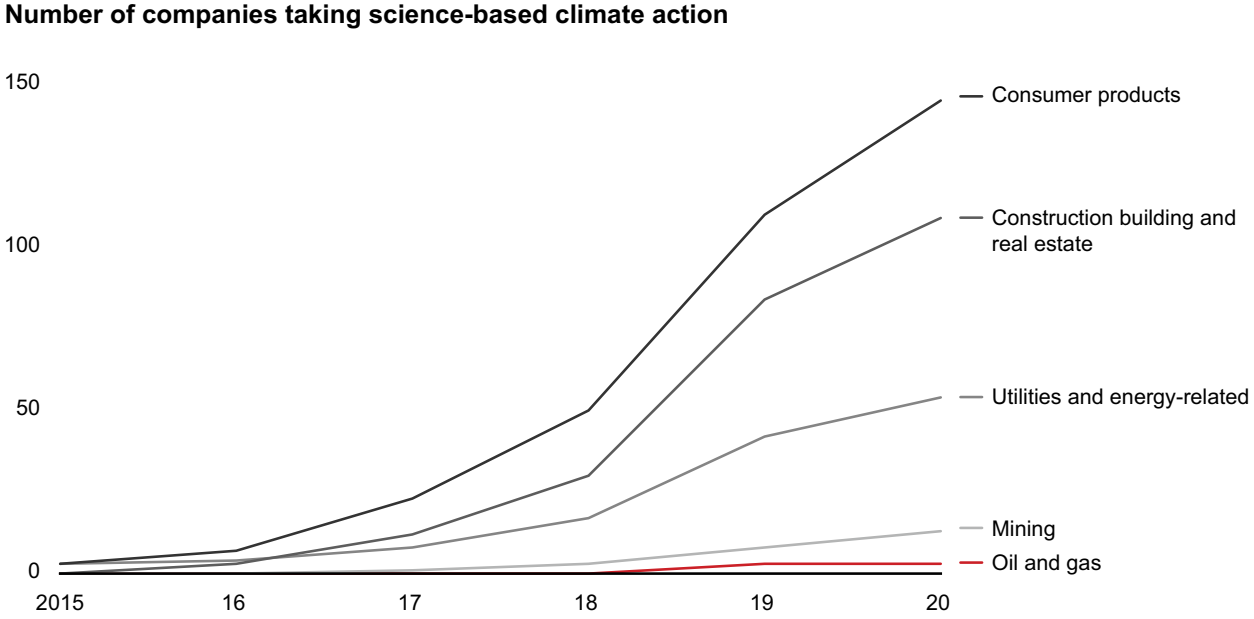
- Many companies have set ambitious decarbonization goals in recent months, responding to pressure from activist investors and consumers.
- Delivering on those ambitions won't be easy. Bain research finds that nearly half of all sustainability initiatives fail to reach their goals.
- Leaders set a clear ambition, develop a bankable plan, and embed the goals of carbon reduction in the company. They also recognize they're part of a broad ecosystem and work with others to achieve common goals.

Climate change was racing up the corporate agenda before Covid-19. Some thought the pandemic would delay action on the climate, given its longer horizon. But in 2021, climate action looks more urgent than ever. Nearly every large company has announced bold decarbonization ambitions, many that include not only the emissions from their own operations, but also those along the supply chain and through the end use of their products.

Boards and management are under pressure from activist investors and highly engaged consumers to pursue those goals. Energy and natural resources companies are also feeling the pressure from insurgents that threaten to take market share with more sustainable products, whether that's renewable electricity, alternatives to animal protein, or fuels that emit less carbon.

Delivering on these ambitions is proving difficult, particularly for energy and natural resources companies when compared with other industries *(see Figure 1)*. Bain research finds that across industries, sustainability programs have a higher chance of failure (47%) than the 20% failure rate for all change efforts. As with other change programs, companies need to build new capabilities, learn how to measure things in new ways, and hire fresh talent.

Figure 1: Oil and gas, mining, and energy utility companies trail other industries in their climate commitments



Note: Companies that have either committed to or set targets with the Science-Based Targets initiative
Sources: Science-Based Targets Initiative; annual reports; company sustainability reports

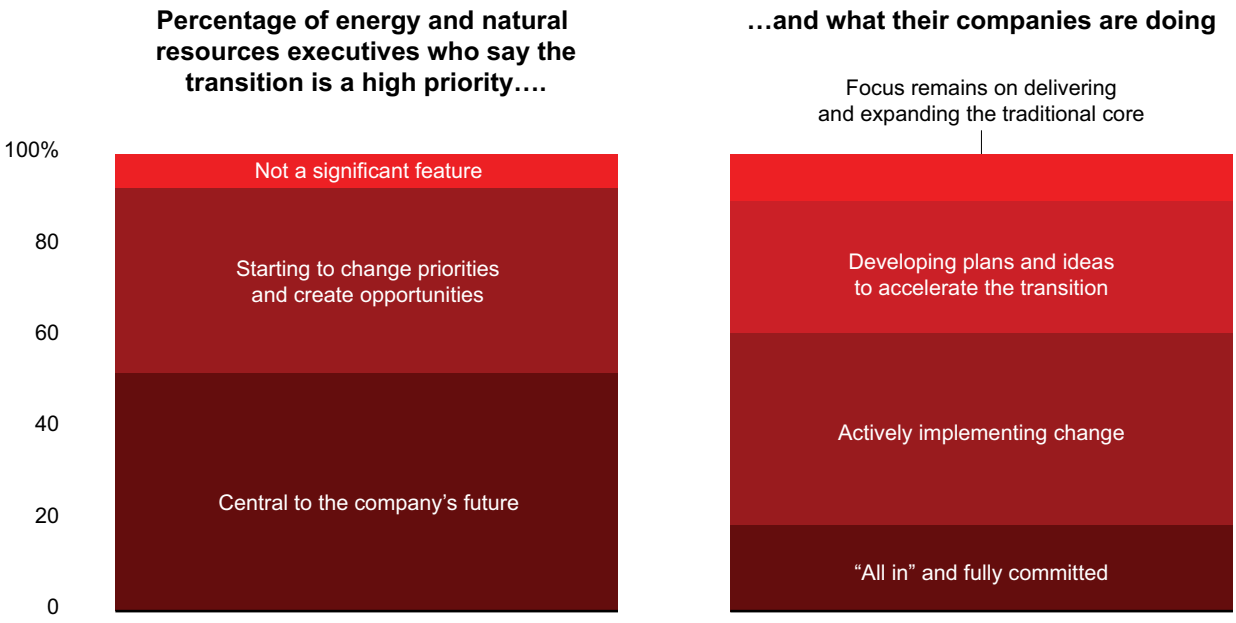
Even so, decarbonization stands apart from other change programs, in several ways:

- It takes a long time, often decades instead of years or months.
- People outside the company (such as regulators and investors) can have as much effect on priorities as leaders within a company.
- New technologies and other disruptions can force a shift in strategy, and long-term investment requires a leap of faith in the future.

On the upside, there's ample opportunity for companies that learn how to move quickly toward their climate goals, primarily because doing so inevitably involves expanding the portfolio to include new lines of low-carbon business. (For more, read the Bain Brief "When Less Carbon Means More Growth.") New products, new markets, and new ways of working are all part of the path to net zero—changes that can make a company more attractive to investors and customers, who are measuring corporate performance in broader ways.

Half of all energy and natural resources companies have put the energy transition at the center of their strategy, and 41% say they're shifting priorities to take advantage of new opportunities. About 40% say they're already implementing changes *(see Figure 2)*.

Figure 2: Half of executives are making the energy transition central to their strategy, and about 40% are already implementing change



Source: Bain ENR Transition Survey, October 2020 (n=69)

The companies moving fastest on this path follow similar patterns: leadership aligns on the ambition, develops a bankable plan, and then works to embed decarbonization into the fabric of the organization. At the same time, they learn to see themselves as part of a broader ecosystem, reaching beyond their own organization, working with partners, suppliers, policymakers, and customers to help them in their journey.

Set the ambition

Customers and investors are urging companies to set more ambitious net-zero targets, which aim to reduce a company's emissions as much as possible and mitigate the remainder by purchasing offsets that remove carbon from the atmosphere. But these targets need to be feasible, with a clear path to success. Most of these goals include not only Scope 1 and 2 emissions (from your own operations and from the energy used to conduct business), but also the Scope 3 emissions that are usually much more extensive, since they include upstream suppliers and the downstream use of products. Although many companies have announced net-zero ambitions 25 or 30 years into the future, it's important to have a realistic path with verifiable signs of progress toward that goal, if the commitment is to be taken seriously.

Develop a bankable plan

Leaders develop a plan that includes strategic portfolio choices, operational improvements, and investments in offsets, such as forestry projects that preserve or increase natural carbon sinks. For example, many oil and gas companies are rebalancing their portfolios, shedding fossil-fuel assets and investing in renewable energy. Most can also find ways to reduce emissions in their operations. Even so, most won't be able to reach net zero without purchasing offsets, so they'll need to find ways to validate offsets and make sure they're contributing their full measure to the net-zero equation.

Companies prioritize these initiatives by assessing the potential for each and determining which ones are most feasible and fastest to implement. As technologies improve, regulations change, and the price of carbon rises, they'll have to rebalance the elements of their plan and be willing to change emphasis as opportunities arise.

Embed carbon reduction in the organization

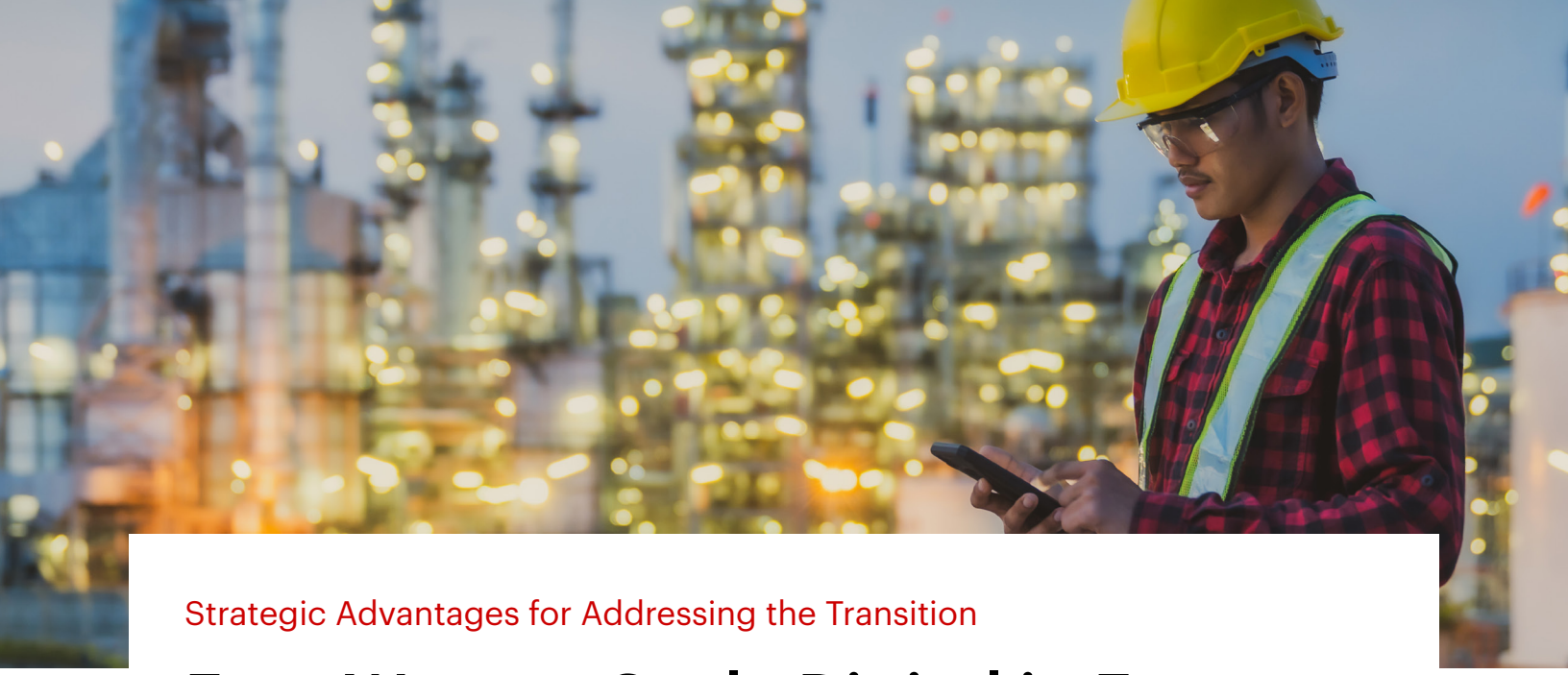
Even the most carefully crafted decarbonization plan won't deliver results without an organization and operating model designed to move the needle. Embedding the plans in processes, budgets, and metrics can ensure continuing advancement. Decarbonization is likely to be on the agenda for 10 years or more, but it's not likely to be the top item on the agenda. So companies need to balance decarbonization initiatives with other business priorities, removing obstacles that can thwart success.

Engage with others

To succeed in their net-zero ambitions, companies need to view themselves as part of a broad ecosystem that includes investors, suppliers, customers, competitors, regulators, and other stakeholders, including nongovernmental organizations and local communities. Even more than before, they need constructive conversations with different types of organizations, finding ways to create mutually beneficial solutions. Fortunately, climate change and decarbonization are proving to be topics that bring stakeholders together.

Some of these collaborations may bring together many companies and policymakers, such as Denmark's climate partnerships, which draw on the expertise of the private and public sectors to develop incentives and regulations for decarbonizing the country's energy sector. (For more, read "Net Zero: From Political Goals to Industry Actions.") Other examples will look more like technology development partnerships, like the collaboration between Anglo American mining and Umicore to research and develop technology that could make it easier to use hydrogen in fuel-cell electric vehicles.

These and other examples show that to reach their net-zero goals, companies are raising their climate ambitions and developing strategic roadmaps that include portfolio rebalancing, more energy-efficient operations, and investments in offsets. Some are reorganizing their leadership structure to ensure that accountability for reaching these goals runs from the senior ranks through the entire organization. Finally, recognizing that they can't do it alone, companies are changing the way they work with partners, investors, and policymakers, since they share responsibility to develop constructive solutions that will move everyone closer to net zero.



Strategic Advantages for Addressing the Transition

Four Ways to Scale Digital in Energy and Natural Resources Companies

Digital technology is a key enabler for operations, commercial excellence, product development, and organizational and sustainability goals.

By Joachim Breidenthal, Laurent Migom, and Natalie Naidoo

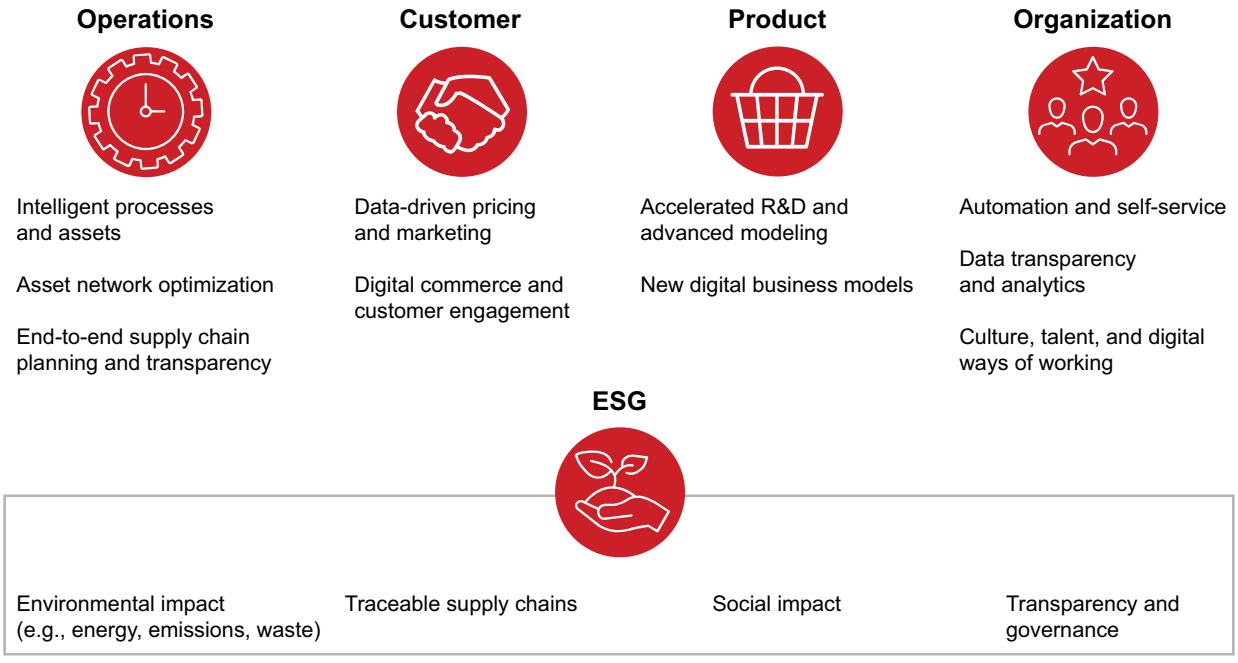
At a Glance

- Digital technologies are important enablers of change in energy and resource companies and are accelerating efforts to adapt to the energy and resource transition.
- Nearly every company has a successful pilot to share, but it's proving harder to scale these experiments into full-scale digital transformations.
- Some of the reasons that initiatives flounder include an inability to focus on the most valuable projects, a lack of clarity on who's accountable, and pilot programs that weren't designed to scale.
- To scale digital initiatives successfully, companies focus on the cases that will deliver the most value, prepare to scale from the beginning, and put in place the right orchestration.

Digital technologies, and the new ways of working that accompany them, are proving to be critical enablers for a broad spectrum of capabilities in companies across industries. Energy and natural resources companies are accelerating digital transformation efforts across a wide range of use cases, such as improving productivity in operations, elevating customer experience, pursuing new business models, or enhancing organizational performance.

Digital technologies are also accelerating energy and resource companies' efforts to reach their environmental, social, and corporate governance (ESG) goals. Digital can not only improve efficiency and free up funds for the energy transition, it can also have a direct impact on the environmental footprint, supply chain traceability, or governance transparency. One global chemicals group, for instance, used digital technology to create better transparency on its environmental performance, which has helped it reduce energy consumption and carbon emissions. A European energy company deployed technology to automate GPS-guided bulldozers and trenchers to improve productivity and reduce costs for the construction of solar plants. And a global supplier of agricultural commodities successfully commercialized and scaled a sustainability platform that provided transparency on a range of ESG goals across the entire supply chain and for a range of food categories *(see Figure 1)*.

Figure 1: Digital technologies facilitate new capabilities across the company, including environmental, social, and governance principles



Source: Bain & Company

Unfortunately, while nearly every company has a successful pilot story to share, very few have scaled up their digital experiments to the point of delivering significant value for the entire organization. Bain's research finds that only 8% of companies say they're getting their money's worth out of their investment in digital. What makes digital so much harder than other transformations, and what have some companies learned that has helped them beat the odds?

Among the reasons that many efforts struggle:

- **lack of focus** on scaling the few cases that will make the difference
- **pursuing technology for technology's sake,** without a clear business problem statement
- **inability to scale** pilots that succeeded in controlled environments, but were too fragile to accommodate real-world conditions in the field
- **unclear accountabilities and governance** that employed a clear strategy and roadmap, but had little follow-through because the line leadership wasn't bought in
- **difficulty sustaining**, so after a couple months, as the impact deteriorates, teams went back to old ways of working
- **too much risk** that made it difficult to experiment if the cost of failure seemed too high
- **lack of change management**, particularly in painting a compelling picture of what the positive future will look like. Some critical stakeholders worried about the impact of digital change on individuals or didn't buy into the benefits digital has to offer

The details may differ, but the themes are consistent: not enough buy-in from the front line, not prioritizing the digital effort, failure to scale and sustain, and, ultimately, results that don't flow to the bottom line.

Making business transformation the goal

By contrast, companies that have successfully scaled their digital initiatives treat these as critical business transformations. The ones that scale and stick are those that embody the business goals of the initiative, deploy technology in the service of those goals, and ensure continuous sponsorship and accountability. In our work, four actions have been crucial for scaling digital transformations.

Focus on value. Since digital transformations are really business transformations, they need to focus on business priorities and scale the few initiatives that will create the most value. It may seem obvious to focus on problems that deliver results, but transformations often gravitate toward the issues that can be solved rather than what the company *should* solve. Teams need to avoid becoming distracted by technology opportunities that don't sustain or create value or are too complex to rapidly deliver results. Better to focus on initial cases that combine high value with ease of deployment to

build momentum, and over time graduate to more complex situations. This demonstrates the value of implementation and scaling and begins to build a track record.

One energy company that had run several pilot projects found it was getting very little return on its investment and solving few business problems. A fresh analysis identified boiler reliability as critical to efficiency. While there was pressure to chase a technology solution for predictive maintenance, the team deconstructed the problem and decided this was one case to scale because it delivered significant value. It then launched pilots that mixed traditional condition monitoring with advanced analytics.

Within three months, this initiative identified several subcomponents on the brink of failure, which it avoided through preventative maintenance, saving enough to cover the cost of the project up to that point. It then went on to target benefits equivalent to 10% of the asset group's value. The lesson for this group: Focus on what creates value and don't feel compelled to develop a completely advanced solution if a mixture of traditional and new measures will get the job done.

Prepare to scale from Day 1. Initiatives are more likely to scale across the company when designed with that goal in mind. For example, a mining company began transforming its operations by looking for similarities in technology infrastructure, capabilities, and the constraints and pain points in its production processes that could unlock material value. This helped the company identify a set of scaling vectors—that is, repeatable themes (for example, business problem, situation, technology, and capabilities) that it could scale rapidly, allowing it to gain valuable experience quickly. Taking the example of operations, these scaling vectors can be along specific production assets, a process, or a piece of equipment that can be repeated across the organization. Other scaling vectors may focus on technology similarities and capabilities, or even simply a repeatable approach or capability for deploying the application.

Orchestrate to enable speed. Digital transformations are more cross-functional than other improvement efforts, and they often demand new capabilities. So it's critical to update the operating model in ways that provide transparency, alignment, and clarity on decision making for a range of issues, including priorities, funding, partnerships, and resource deployment. If possible, go with the grain of the organization's existing operating model. It helps to stand up a team that can design pilots that can be scaled up rather than retrofitted once they're in motion.

A chemical company had been working on its digital transformation for more than a year but was having trouble scaling up from low-impact pilots. Each plant had unique challenges and preferred its own, customized solutions, which led to complex decisions about resources and funding between the center and operations. Three changes in the digital operating model moved the company forward.

- First, it put in place dedicated scaling teams to support delivery, propagate knowledge across units, and anticipate technology and capability requirements.

- Second, it put a strong leadership governance in place with clear focus on three solutions that created 80% of the value, with a central budget to support the first wave of deployments.
- Third, it launched a change and engagement approach, including storytelling that captured hearts and minds.

The changes helped the company save more than €30 million over the first six months—50% above target savings—primarily through use of analytics that optimized processes and improved productivity. The program is on track to save three times that amount over the next three years.

Operationalize to sustain value. When new technologies or processes don't fit into the way work gets done, the innovation can sit unused by the front line. Successful transformations preempt this problem by designing for and selectively rewiring processes to take advantage of the digital innovation—that is, *operationalizing* it to create closed feedback loops from the field and capture all the intended value.

This includes investing in capabilities that will let the company take advantage of an opportunity when it arrives, whether that's hiring the right talent or fostering a culture that encourages innovation and risk taking, or adapting the funding or procurement model to implement digital programs at speed. Companies can then invest more confidently in disruptive change, which could be new technology, a new line of business, or an entirely new business model.

One petroleum company identified an opportunity to improve its yield. In doing so, it developed a repeatable advanced analytics and Agile method that could be used across multiple manufacturing assets. The company operationalized and sustained the program by embedding the method in governance and ongoing business rhythms, while ensuring sponsorship from senior business and line leadership, communicating the need for the change, and setting up forums to share successes and learn from failures.

The costs of implementing digital continue to fall as technologies mature and as companies and their people gain experience working with technology. As energy and natural resources companies work to enable the energy and resource transition, the benefits of digital technology—cost reduction, improved productivity, greater accuracy, and new business opportunities will undoubtedly be key enablers to making positive change while maintaining a competitive edge.

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