

MOST INNOVATIVE COMPANIES 2022

Are You Ready for Green Growth?

September 2022



BCG

Boston Consulting Group partners with leaders in business and society to tackle their most important challenges and capture their greatest opportunities. BCG was the pioneer in business strategy when it was founded in 1963. Today, we work closely with clients to embrace a transformational approach aimed at benefiting all stakeholders—empowering organizations to grow, build sustainable competitive advantage, and drive positive societal impact.

Our diverse, global teams bring deep industry and functional expertise and a range of perspectives that question the status quo and spark change. BCG delivers solutions through leading-edge management consulting, technology and design, and corporate and digital ventures. We work in a uniquely collaborative model across the firm and throughout all levels of the client organization, fueled by the goal of helping our clients thrive and enabling them to make the world a better place.

Contents

01 The Sustainability Innovation Gap

- The Top 50 Lead on Innovation and C&S
- There's a Will, but Is There a Way?
- Closing the Gap

09 How Sustainability Leaders Innovate

- Focusing on High-Impact Innovation Domains
- Managing the Funnel
- Embracing External Engagement
- Performance Management

15 Digging Deep for Sustainable Innovations

- Stewardship and Value
- Levels of Ambition
- The Journey to Carbon-Neutral Shipping
- Sectors and Barriers
- Flying at Net Zero
- From Leadership to Stewardship

22 About the Authors

23 Acknowledgments

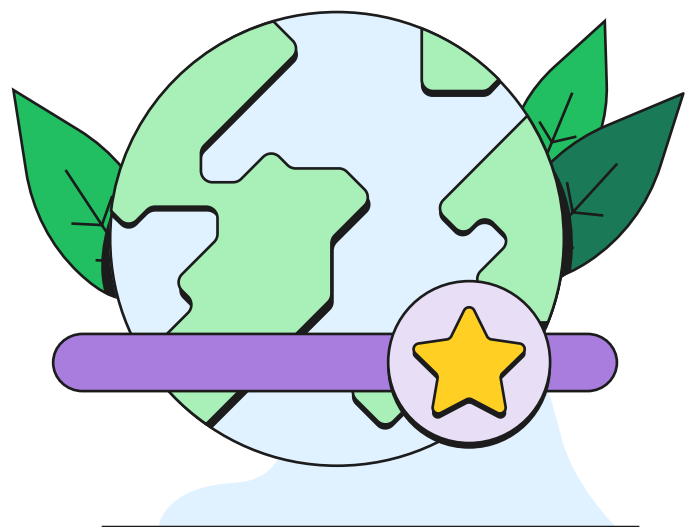
23 Methodology



The Sustainability Innovation Gap

Are you ready? Last year in our global innovation survey, we asked if companies were prepared to turn innovation investments into results. We found that commitment (prioritizing innovation and investing behind it) was high but readiness levels (having well-developed and practiced innovation capabilities) were mixed.

The same question takes on both specificity and urgency in 2022. This year, for the first time, we asked about the importance of climate and sustainability (C&S) in innovation. Two-thirds of the companies ranked C&S as a top corporate priority. More than half reported that they are committed C&S innovators, meaning that they rank both innovation and C&S among their top three priorities. But only about one in five companies is ready to take effective action.



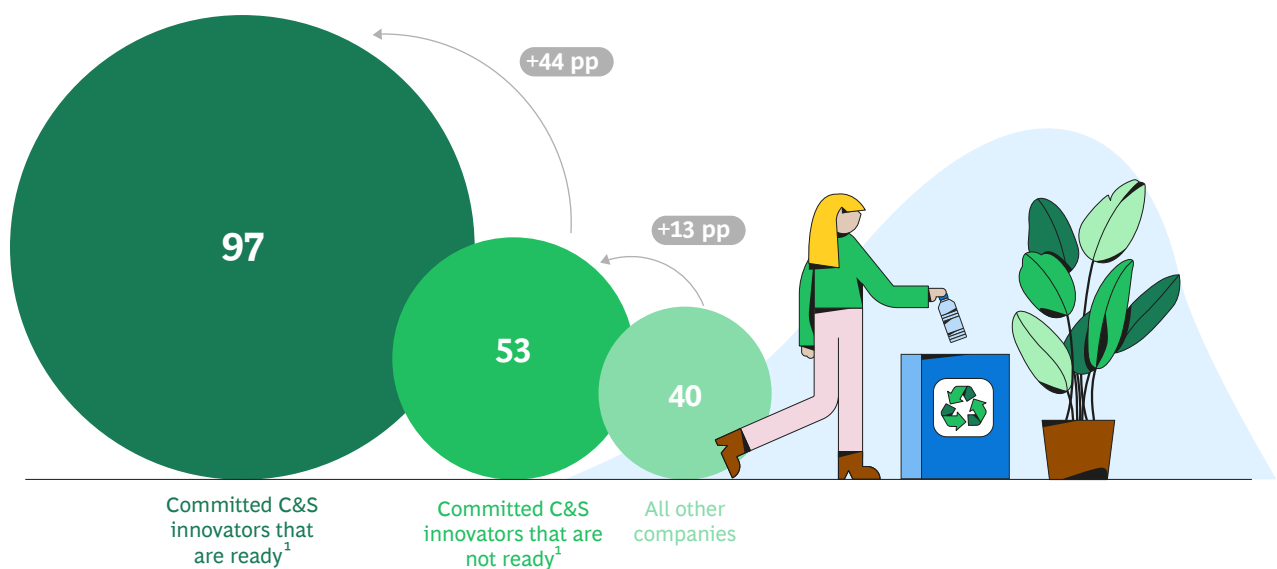
These companies have already incorporated C&S priorities into their innovation engines. They can move fast because they have put time, energy, and resources into building the capabilities they need. (See Exhibit 1.) They are ready to develop product, process, and business model innovations that can deliver. For them, C&S is a matter of redirection rather than reinvention.

As more global companies announce net-zero pledges almost daily, the innovation readiness gap between commitment and capability becomes an existential problem. This year’s report looks at the innovation readiness gap in sustainability from three perspectives. In this section, we examine the state of companies’ current commitment and capabilities with respect to sustainability and examine how 2022’s 50 most innovative companies measure up.

In “How Sustainability Leaders Innovate,” we look more closely at four ways in which leaders are bringing their innovation capabilities to bear on the sustainability challenges they face. In “Digging Deep for Sustainable Innovation,” we assess the types of more radical moves that ambitious leaders will need to consider if they want to go the last mile toward establishing systemic sustainability practices, not only for themselves but for their industries, partners, and value chains.

Exhibit 1 - C&S-Ready Innovators Incorporate Sustainability into Their Innovation Systems More Extensively Than Others Do

Companies that have incorporated climate and sustainability into their innovation platforms and practices (%)



Sources: BCG Global Innovation Survey 2022; BCG analysis.

Note: Question: “To what extent is climate and sustainability incorporated into your innovation platforms and practices?” pp = percentage points.

¹Ready innovators score 81 or higher on BCG’s 100-point innovation-to-impact (i2i) benchmarking framework.

The Top 50 Lead on Innovation and C&S

Let's start with the 50 most innovative companies for 2022. Little surprise, many are C&S committed and ready C&S innovation leaders. Apple, Microsoft, Amazon, Alphabet, and Tesla again take the top five innovation positions, and most of the rest of the top 10 remains unchanged as well. (See Exhibit 2.) One exception is Moderna, which jumps into the top 10 from number 42. Pfizer, meanwhile, remains in our top 20. Four companies—ByteDance, Nvidia, Panasonic, and Zalando—joined the top 50 for the first time in 2022. Eight others returned after an absence of at least one year. As has been the case for the past five years, more than half of the companies on the list are based in North America.

The automotive industry made a major move upward, with General Motors (at number 42) and Ford (at number 43) rejoining the top 50, and with Tesla (at number 5) and Toyota (at number 21) holding their positions. Hyundai (at number 33) is another automotive holdover from the 2021 list. Automotive also ranks second among sectors in the percentage of companies prioritizing C&S, a reflection of the industry's commitment to electric vehicles (EVs) and mobility.

The tech sector shares that commitment, of course, as evidenced by well-publicized autonomous vehicle efforts that Apple, Google parent Alphabet, and others have undertaken. Nvidia (number 15 on the top 50 list), which is known for its high-powered chips used in machine learning applications, is contributing to the development of autonomous vehicle technology through the DRIVE Hyperion platform (which was featured at the annual CES event in Las Vegas in January 2022), after partnering in 2018 with Bosch (number 26) and Daimler to build AI-driven robotaxis.

Exhibit 2 - The Most Innovative Companies of 2022



Source: BCG Most Innovative Companies (MIC) Report 2022.

Note: Industry classification based on Capital IQ; some companies play across industries.

¹Facebook became Meta in 2021; in previous BCG Most Innovative Companies reports, it appeared under the name Facebook.

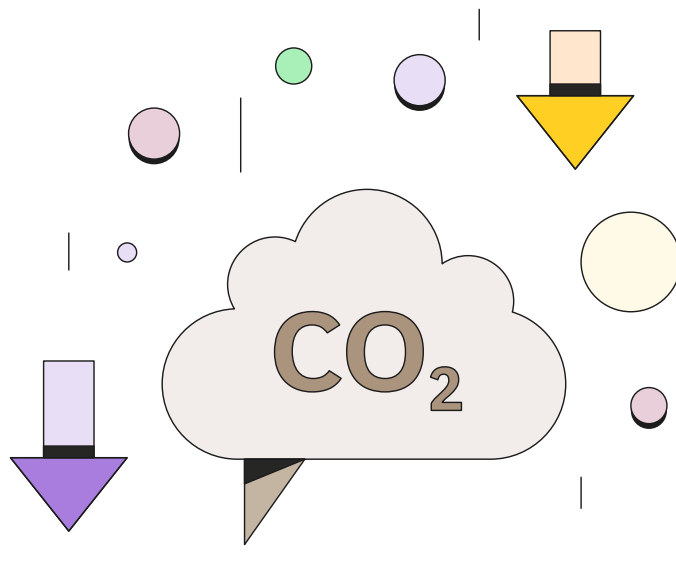
Many of the companies on the top 50 list for 2022 were among the earliest companies to embrace environmental, social, and governance (ESG) principles and establish decarbonization commitments. Almost 80% (39) qualify as top C&S innovators, according to global peer votes, and nearly 90% have top-quartile Refinitiv ESG scores—an attainment that, according to Refinitiv, “indicates excellent relative ESG performance and high degree of transparency in reporting material ESG data publicly.” (Although such scoring systems have come under criticism and may have shortcomings, they are among the best-in-class measures available today.)

There’s a Will, but Is There a Way?

BCG has surveyed trends and developments in innovation since 2003, and we published our first Most Innovative Companies report in 2004. Almost 20 years ago, we noted that “developments in technology have amplified the challenges and opportunities associated with innovation.” The climate crisis brings the importance of technology into even sharper focus. Innovation that builds on both existing and emerging technologies is essential to combating climate change. Companies need to apply existing tech in new ways to create climate-friendly products and processes in the near term. Advanced tech is key to decarbonizing emissions-intensive industries over time.

Members of the top 50 aren’t the only companies that prioritize C&S: 65% of respondents in our 2022 survey, including a majority of those from private-sector companies, ranked C&S as a top-three priority, and about a quarter cited it as their organization’s number-one priority. (See Exhibit 3.) Industries with the highest scope 1, 2, and 3 emissions prioritize C&S the most: durable goods (85%), automobiles and components (78%), and energy (77%). Those prioritizing C&S the least include the public sector (48%), software and services (52%), and consumer goods (52%).

Commitment is also high: 56% of companies rank both innovation and C&S among their top-three priorities. (See Exhibit 4.) This is a promising foundation for progress, but there is also a rub. As we found last year, a substantial readiness gap exists among all companies—including committed innovators—and threatens to hold back advances.



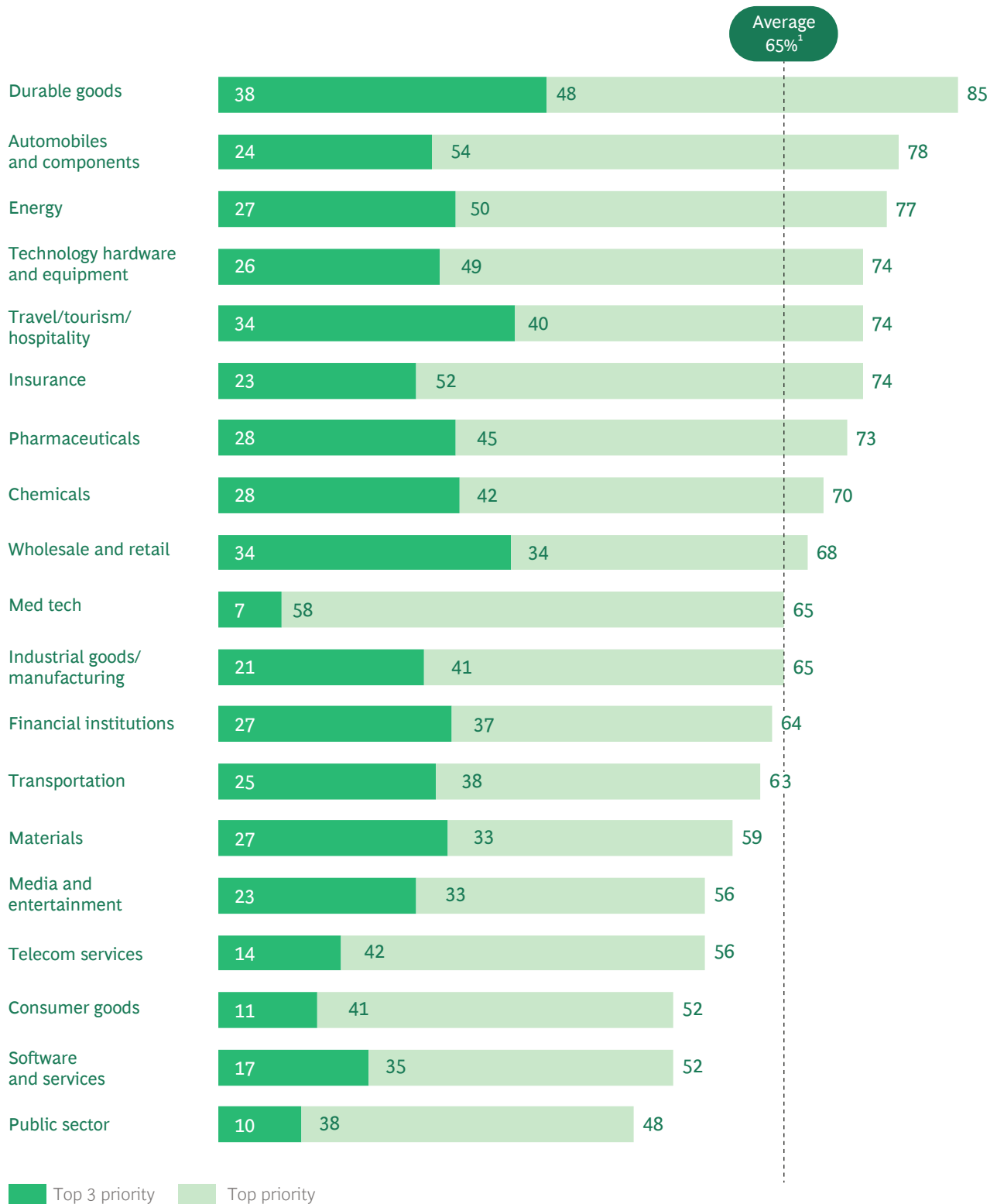
We applied BCG’s innovation-to-impact benchmarking framework (*i2i by BCG*) to committed C&S innovators to assess the readiness of their innovation systems. A perfect *i2i* score is 100. Among committed C&S companies, 28% scored 81 or higher, marking them as “ready” innovators, indicating that nearly three-quarters of committed C&S innovators need to raise their innovation game, and 80% of all companies face a steep learning curve.

There is also encouraging news. We have written before that meeting the sustainability challenge requires using a combination of **big data**, **deep technology**, and **strategic ecosystems** to tackle the complexity and industry-level transformations involved. Consider the multiple consortia of auto OEMs, suppliers, tech companies, software designers, chip manufacturers, battery makers, telcos, mobility providers, and others that have come together around the idea of autonomous vehicles.

Committed C&S innovators are more likely to engage with external partners, and ready innovators are 44% more likely to do so than those that are simply committed. High-emitting companies are 20% more likely than low emitters to target the kind of deep-tech solutions they’ll need to substantially decarbonize.

Exhibit 3 - 65% of Companies Cite Climate and Sustainability as a Top 3 Priority

Respondents citing climate and sustainability among their company's top priorities (%)

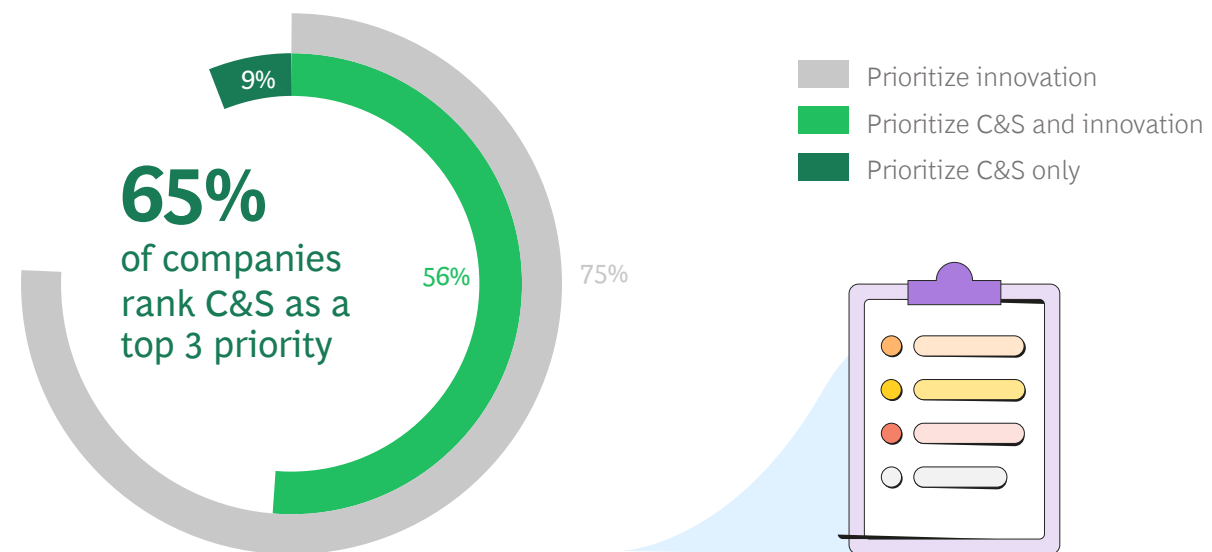


Sources: BCG Global Innovation Survey 2022; BCG analysis.

Note: n = 1,010 for global respondents. Because of rounding, not all bar totals equal the sum of the percentages given for their bar segments.

¹Refers to identifying C&S as one of the top 3 priorities.

Exhibit 4 - In 2022, 56% of Companies Rank Both Innovation and C&S Among Their Top 3 Priorities



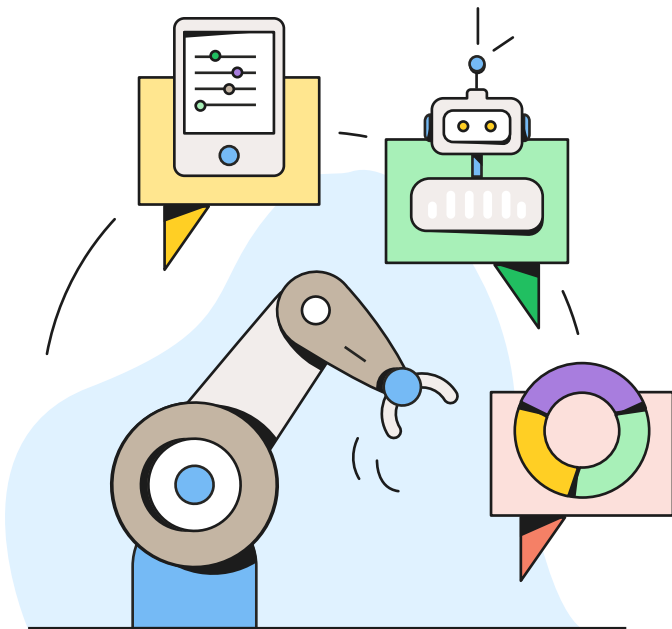
Sources: BCG Most Innovative Companies 2022 report; BCG analysis.

Closing the Gap

As sustainability moves up the agenda in boardrooms and C-suites everywhere, the importance of innovation rises commensurately. But innovation—be it in products, processes, or business models—is not a siloed function and does not take place in a walled-off lab. Progress depends on the same human and technological capabilities that drive success elsewhere, including collaborating, digitizing, harnessing data, building artificial intelligence (AI), developing the requisite human skills, and implementing cross-functional teams and agile ways of working.

Many of the CEOs we talk to report that they are currently wrestling with six issues as they try to scale up their innovation capabilities:

- Surfacing differentiated customer insights that unlock new opportunities and concepts
- Benchmarking their innovation systems to identify and implement upgrades
- Cleaning up the innovation pipeline and optimizing allocations of human and financial capital
- Putting agile, customer-centric teams to work on high-promise opportunities
- Translating C&S aspirations into targets, mechanisms, and desired behaviors across their innovation systems
- Mapping deep-tech money flows and the evolving IP landscape to surface opportunities and identify threats

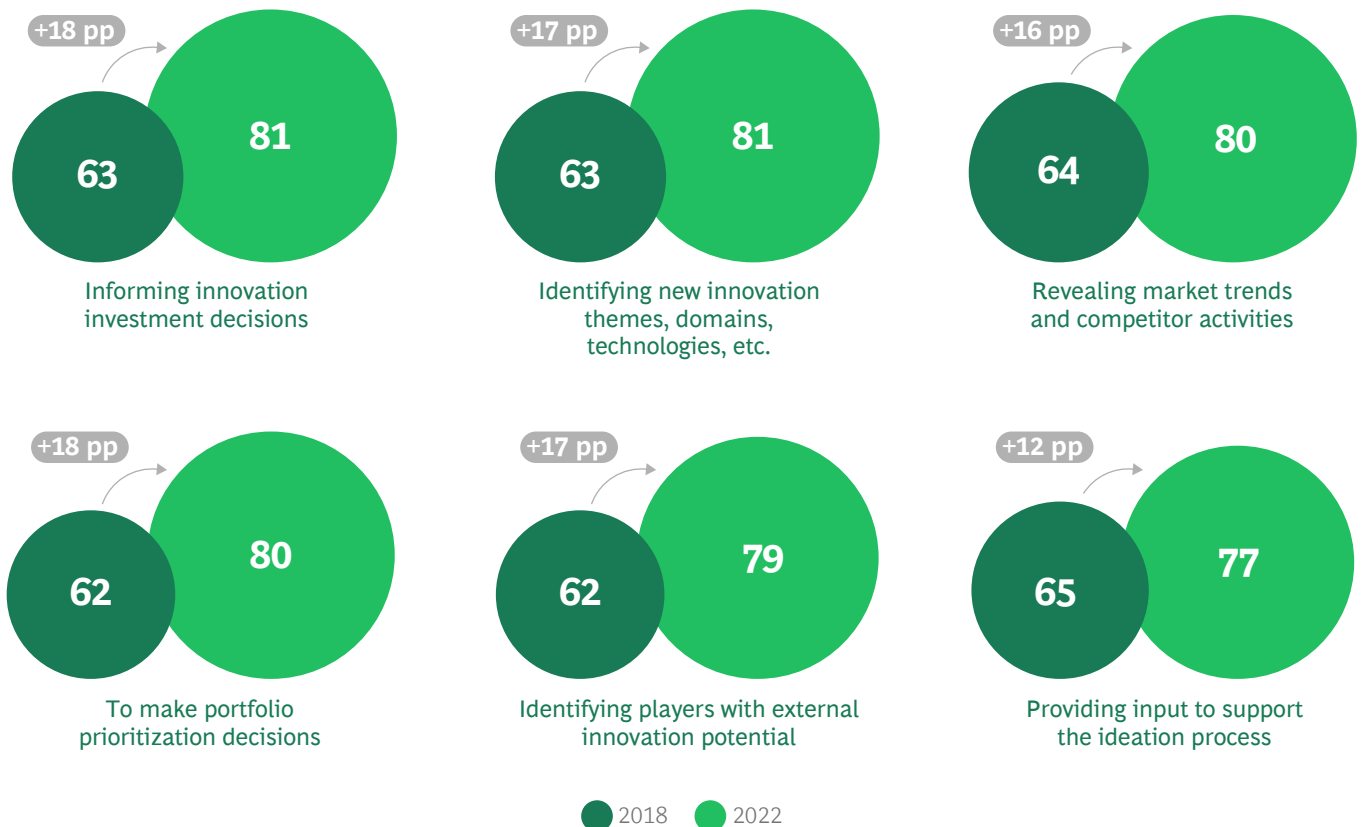


Companies that do not have these fundamental building blocks in place—which our research into such related topics as [digital transformation](#), [AI](#), and [data maturity](#) indicates are still the majority—will find themselves on the wrong side of widening gaps in both C&S and innovation.

The good news is that gaps can be closed and leads are not insurmountable. Companies report that their data and analytics capabilities have improved considerably in the past several years. (See [Exhibit 5](#).) Ready companies are currently about 20% ahead of others across all use cases—and extending their advantage. C&S-ready innovators, in particular, show rising productivity from new ways of working, suggesting that they may have found a sustained source of advantage as in-person, remote, and hybrid working models find a new equilibrium. (See [Exhibit 6](#).)

Exhibit 5 - Advanced Analytics Skills Have Improved

Respondents who selected “strong” or “very strong” for each skill (%)

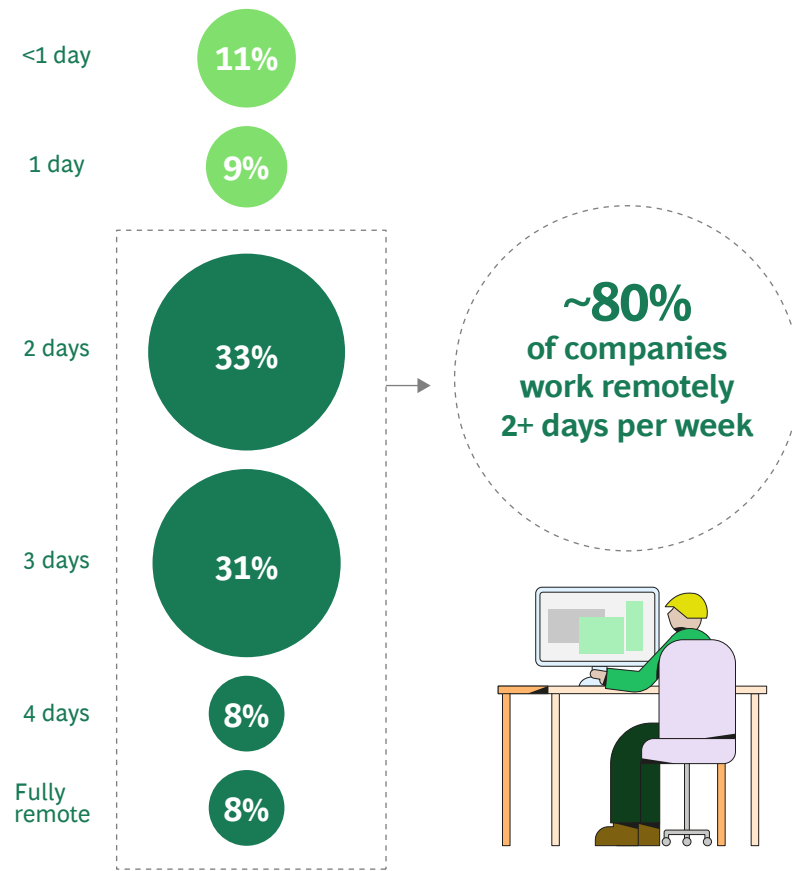


Sources: 2022 and 2018 BCG Global Innovation Surveys.

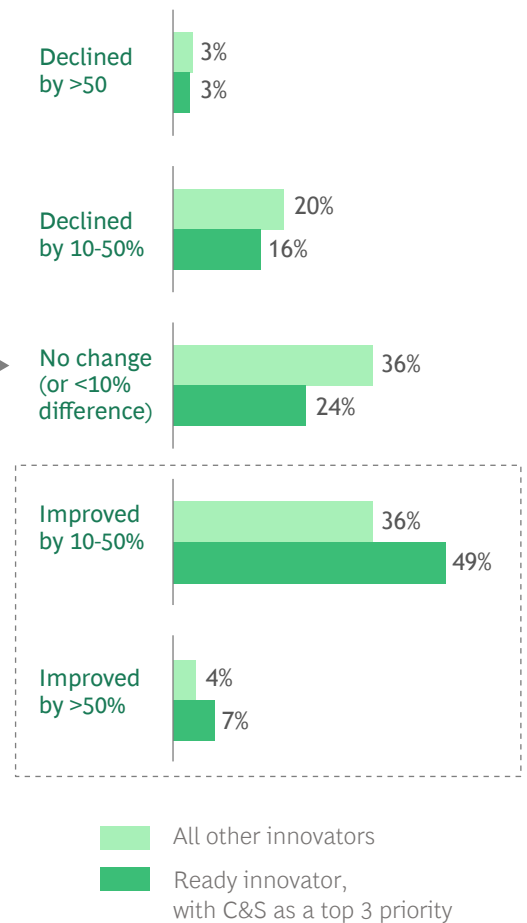
Note: Question: “How would you rate your company’s skill at leveraging big data and advanced analytics to help with each of the following aspects of innovation?” N/A responses omitted. pp = percentage points. Because of rounding, not all percentage-point differences match the difference between the pairs of numbers listed in the circles.

Exhibit 6 - C&S-Ready Innovators Have Seen Greater Productivity from New Ways of Working

How many days a week does a typical member of your innovation or R&D team work remotely (from home)?



How have new ways of working impacted productivity of innovation/R&D activities?



Sources: BCG Global Innovation Survey 2022; BCG analysis.

Note: n = 1,022 (MIC sample). “Ready” indicates a company with a BCG i2i score of 81 or higher.

Companies such as the automotive and tech firms cited above—as well as Nestlé, PepsiCo, and Unilever in food, Neste and Ørsted in energy and power, and Mærsk in shipping—have demonstrated that using innovation to address climate action can **create business advantage and value**.

For example, before the 2022 jump in oil prices, Neste and Ørsted were among the top-performing energy companies in terms of total shareholder return. Mærsk has substantially outperformed the S&P 500, the S&P Transportation Index, and the S&P Global 1200 since 2019.

Companies that do not quickly put their readiness house in order will have difficulty transforming current offerings and assets in ways that reduce their carbon footprint. And the clear evidence is that this will leave them behind competitively.



How Sustainability Leaders Innovate

In innovation, readiness matters. Only 20% of companies are both committed to innovation, meaning that they prioritize and invest in it, and ready to innovate—that is, they possess well-developed and practiced innovation capabilities, as we described in our 2021 [Most Innovative Companies](#) report. These companies outperform. They are up to four times as likely as other companies to generate a disproportionate share of their sales from new products, services, and business models.

In C&S innovation, readiness may matter even more. Lots of companies talk about C&S and pledge net-zero emissions by some future date. But far fewer have started to walk toward net zero, developing the new products, services, and models they'll need to get there. Less than 30% of companies are C&S ready, having recalibrated their innovation engines to act on sustainability as a corporate priority. Like all ready companies, they are opening leads over others that will be hard for the laggards to close.

C&S-ready companies emphasize a number of aspects of their innovations systems more aggressively than other ready innovators do. They start with greater ambitions, which we will examine further in [the next chapter of this report](#). They identify domains to focus on, manage the idea funnel, and have clear performance goals. (See [Exhibit 7](#).) They also engage more actively with partners and even competitors. Let's look at what some leaders are doing in each area.

Focusing on High-Impact Innovation Domains

Leaders find and spotlight the must-win domains—key areas of focus for innovation that they identify through customer-driven insights—that will advance their C&S agendas. They also focus more intensively on product and business model innovation and on innovation from advanced technologies. The best-known example of this may be Tesla (at number 5 on the 2022 top 50 list), which developed both a new type of product and a new business model, thereby disrupting the auto industry. But traditional industry leaders such as Toyota (number 21), Hyundai (number 33), General Motors (number 42), and Ford (number 43) are catching up by focusing their own considerable innovation capabilities on hybrid and electric vehicles. Their suppliers, old and new, are following suit. For example, Bosch “decided to define specific areas of innovation in which we apply our research activities to accelerate the pace of technological progress,” according to its website.

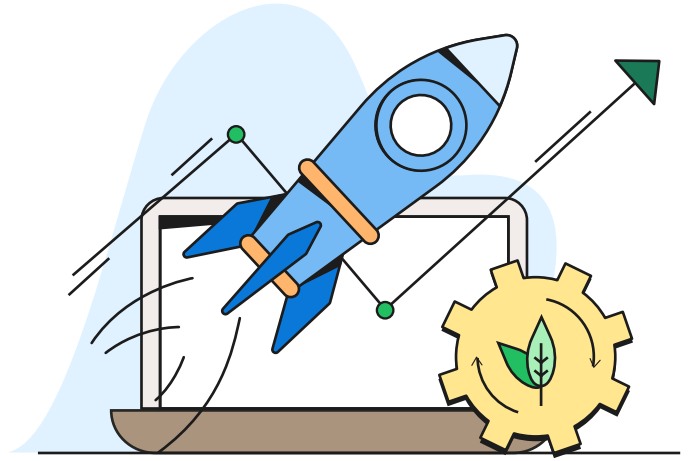
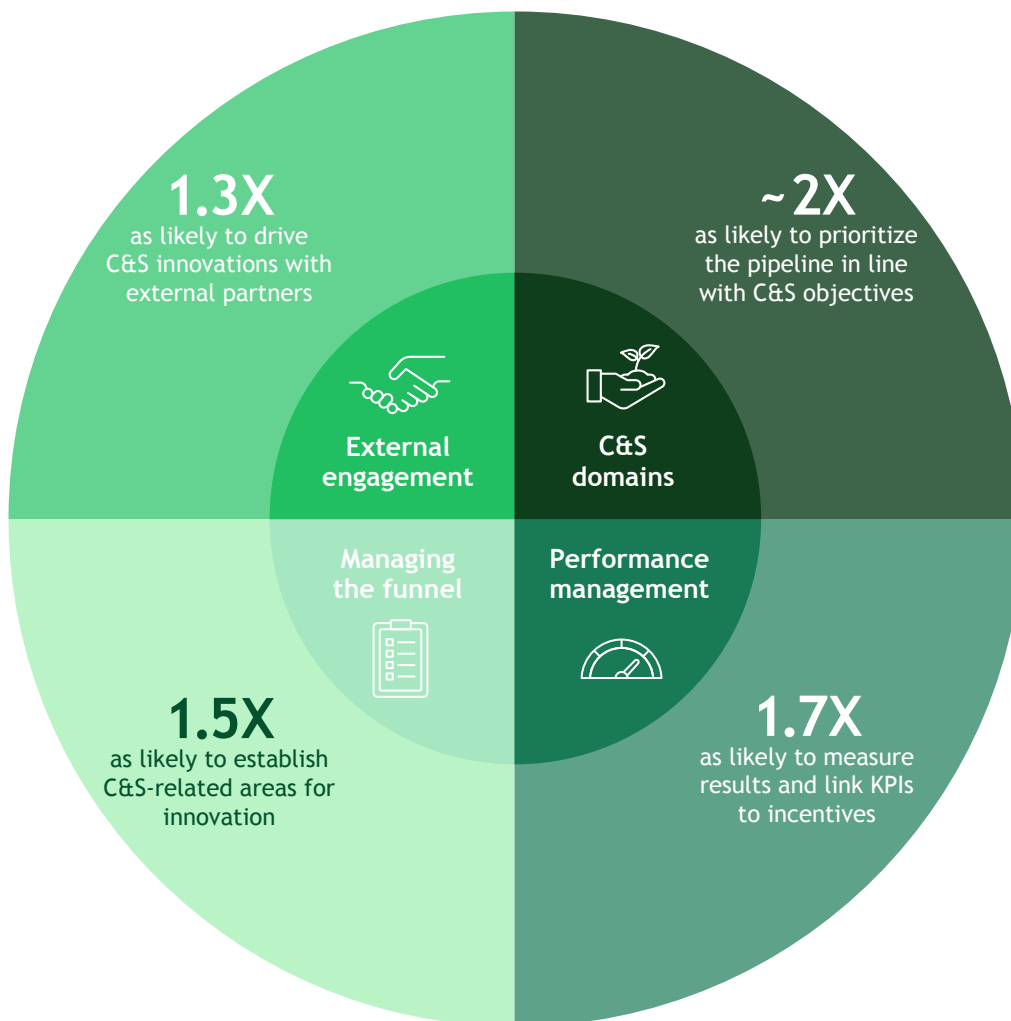


Exhibit 7 - Ready C&S Innovators Realize Differential Impact from Four Key Dimensions of Their Innovation Systems



Source: BCG Global Innovation Survey 2022.

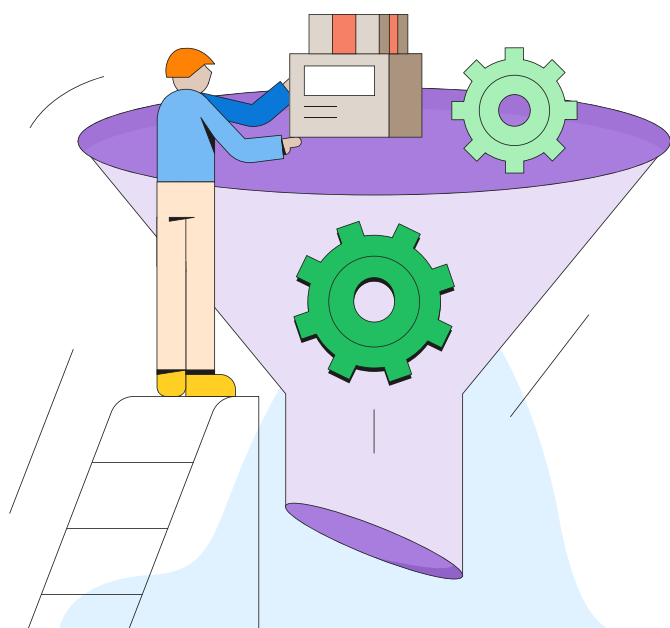
Among the domains making these advances possible and in which mobility players are investing are electric powertrains, AI, autonomous driving capability, and digital connectivity. Companies large and small are active. SiFab, for example, is developing a battery breakthrough that can accelerate the EV transition. Its silicon anode for lithium-ion batteries improves gravimetric energy density by up to 20% over the current industry standard, with increased range.

Alternative protein makers are achieving big advances in the food chain, generating a lot of [consumer interest](#). Their efforts have major implications for our ability to feed a growing global population and to fight climate change. BCG expects [alternative proteins](#) to account for 11% to 22% of all meat, seafood, eggs, and dairy eaten around the globe by 2035.

New food startups have inspired traditional players to put their innovation engines to work. Unilever (at number 50) has set a goal of reaching €1 billion in annual sales from plant-based meat and dairy alternatives by 2025 to 2027. It has also released a number of alternative protein products, including The Vegetarian Butcher “meats,” and plant-based mayonnaise and ice cream. Nestlé (number 49) has introduced a plant-based portfolio of foods around the world, including seafood alternatives and a vegan alternative to its iconic KitKat bar.

Managing the Funnel

Leaders are employing a C&S lens to ensure the prioritization and acceleration of C&S-focused projects. They allocate and reallocate resources across their pipelines to ensure that the pipeline remains viable and strategically aligned as new information becomes available (either internally about the underlying projects or externally in response to market developments).



John Deere, for example, is investing in business model innovation to build a new service- and data-based business that complements its agricultural machinery. To bring the idea to reality, Deere analyzed customer needs, identified relevant innovation domains, and invested progressively in the new capabilities and technology stack it needed to execute effectively.

Deere’s Smart Industrial transformation leverages its investments in the technology stack to drive toward increasingly autonomous vehicles equipped with sensors and AI that help farmers maximize profits while reducing environmental impact. Along the way, Deere has invested progressively in the resources needed to drive its high-priority innovations, directing these investments toward overcoming barriers related to connectivity, data collection and management, and machine capability and autonomy. It has boosted its investments in AI and robotics, for example, increasing the size of its AI team from 50 to 400.

This transformation is the latest step for Deere to continue as the leader in digital-precision agriculture solutions. The innovative technologies behind See & Spray, launched in the market in 2021, permit targeted application of herbicides, reducing input intensity and yielding better outcomes for farmers and for the environment. All of these efforts have enabled Deere to enjoy substantial multiple expansion and shareholder returns in recent years.

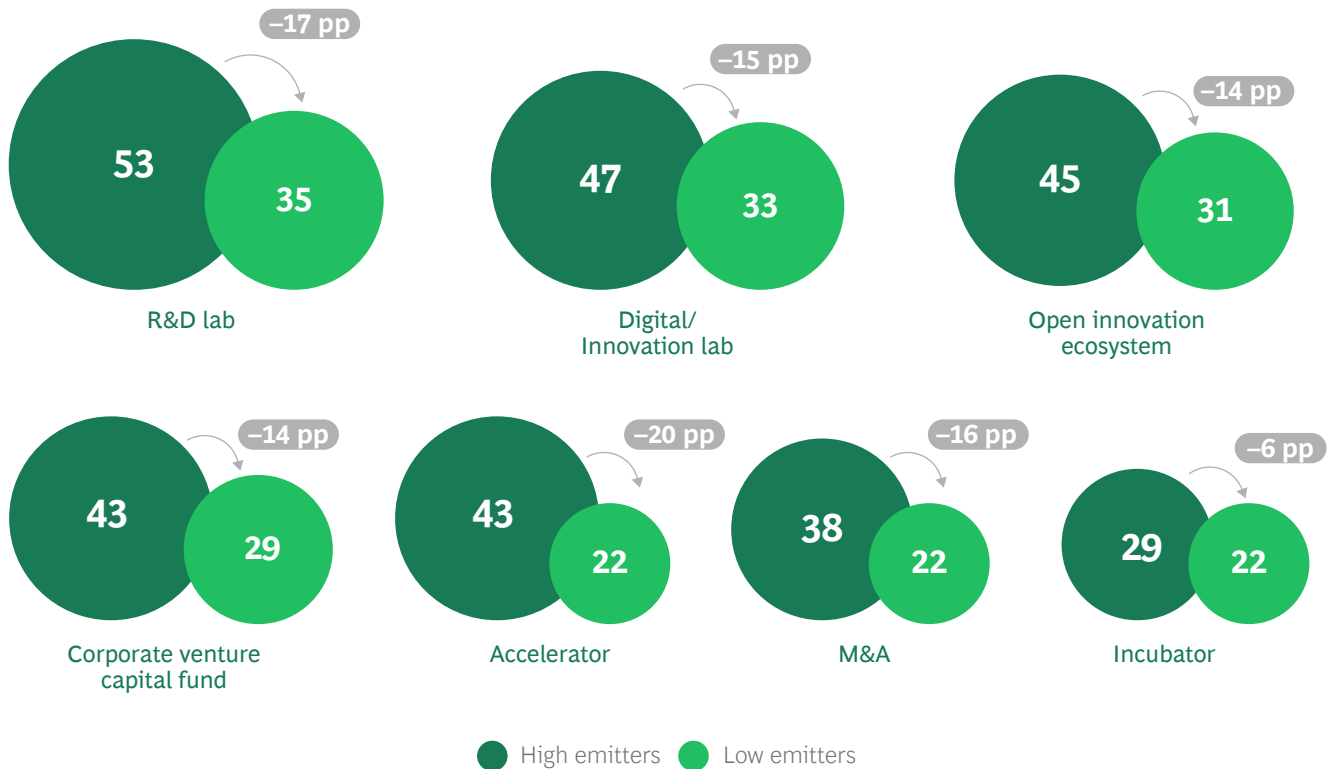
Embracing External Engagement

We have been writing for years about the need for companies to [look outside their own organizations](#) for new ideas and [approaches](#). As the challenges have become increasingly complex, the importance of embracing partners—and even competitors—in platform-based solutions and ecosystems has risen commensurately. C&S leaders today are deploying more innovation vehicles and engaging external partners to expand the aperture for ideas and to bring new capabilities on board more swiftly.

High-emitting companies, such as those in the energy and power generation sectors, have a strong need for sustainable solutions, but in many cases their innovation sophistication is no match for the size and scale of the challenge. Their playbooks tend to involve a wholesale embrace of multiple innovation vehicles, providing a glimpse of a new imperative for companies that seek to rapidly climb the C&S innovation maturity curve. (See Exhibit 8.) They employ internal and external vehicles, such as incubators and venture capital funds. They involve partners, set external ideation targets (to avoid the possibility that internal thinking will shape the pipeline to an excessive degree), and run competing pilots, among other techniques.

Exhibit 8 - More Companies with High Emissions Are Leveraging External Vehicles

Committed C&S innovators who selected “Established, with targeted results/relevant impact for core business” (%)



Sources: 2022 and 2018 BCG Global Innovation Surveys.

Note: Question: “What innovation vehicle do you deploy, and what is their status?” N/A responses omitted. “High emitters” are companies that fall in the top quartile for carbon emissions, and “low emitters” are companies that fall in the bottom quartile. pp = percentage points. Because of rounding, not all percentage-point differences match the difference between the pairs of numbers listed in the circles.

Italy’s Enel Group, a power generation company, coined the term *open innovability* to describe its strategy of combining innovation and sustainability. The company manages a global network of nine innovation hubs and 22 labs that work with external partners. Rather than make equity investments in young companies with new ideas, Enel often serves as the first customer for these startups, running joint pilots and providing access to Enel’s innovation network. It has launched more than 170 innovation challenges, scouted more than 11,000 startups, and incorporated more than 115 ready-to-scale-up small companies into its portfolio.

Lower-emitting C&S leaders are embracing the external approach as well. PepsiCo (number 38 on the top 50 list) started PepsiCo Labs to identify startups pioneering new technologies and to accelerate piloting and adoption of new approaches across PepsiCo. PepsiCo Labs is an enabler of PepsiCo’s Positive Agriculture initiative, which aims “to source crops and ingredients in a way that accelerates regenerative agriculture and strengthens farming communities.”

**Innovation is not a siloed function.
Progress depends on the same
human and tech capabilities that
drive success elsewhere.**



PepsiCo Labs has selected a number of promising startups for pilots within PepsiCo's broader range of operations. One example is N-Drip, an Israeli irrigation company that has developed a system using gravity rather than energy to deliver water to crops. N-Drip cuts water usage roughly in half, reduces fertilizer usage, and increases yields 15% to 40%. To date, N-Drip has set up successful pilots that it has run with PepsiCo in India, South Africa, the US, and Europe.

Unilever (number 50 on the list) has established its Hive innovation center with the goal of creating "the Silicon Valley of Food." Hive seeks to further Unilever's R&D by leveraging the input and involvement of partners from multiple spheres.

Performance Management

Our 2021 analysis identified **five factors** that are especially important to innovation readiness. They are the areas where we found the biggest gaps between leaders and laggards in our i2i scoring system—and where even the leaders still have ample room for improvement.

One of these key factors is performance management. Moving the innovation needle quickly entails linking ambition to measurable KPIs that faithfully report performance on the true drivers of success. Moreover, companies should tie these KPIs to incentives that reward both predictable, incremental progress and successful step-change innovation. Metrics and incentives should recognize leaders who not only push promising new ideas but also identify and ditch failures early in the process.

C&S goals and measurement systems (never mind incentive programs) extend beyond standard metrics for growth, profitability, and ROI. As such, they are still relatively new and fairly complex to design and implement. Many companies are wrestling with how to structure targets and metrics and how to monitor progress, especially with regard to scope 2 and scope 3 emissions, over which companies do not have direct control.



One company that is upgrading its performance system is SC Johnson, the US-based global manufacturer of such well-known brands as Windex, Ziploc, Scrubbing Bubbles, and Glade. The company is taking a progressive approach to including C&S factors—building a data platform and automated tools to track and measure C&S data and make it accessible at key decision points throughout the organization (such as new product development, portfolio management, and planning). This platform takes a broad view of C&S, encompassing plastics and packaging (both the use of post-consumer recycled content and the recyclability and reusability of finished goods), chemistry (in support of ingredient selection and ingredient disclosure and transparency), and carbon, deforestation, and waste and water priorities. SC Johnson management believes that C&S measurement goes beyond building a more efficient reporting mechanism, to include elevating C&S as a critical component of business-case decision making.

Readiness matters. Ready leaders in C&S have demonstrated how quickly they can integrate fast-rising sustainability priorities into their innovation engines and start to produce tangible results. In the process, they are making real progress against global warming, and they are establishing lasting positions of advantage with customers, shareholders, and regulators. Laggards should take note and determine how to raise their own readiness games.



Digging Deep for Sustainable Innovations

Give me a lever long enough and a fulcrum on which to place it, and I shall move the world.

— Archimedes

As if expectations for CEO performance weren't high enough already, the climate crisis has raised the bar. Investors, customers, regulators, and others are looking to big companies to lead in developing C&S solutions.

There are no simple paths to decarbonization, especially when dealing with scope 2 and scope 3 emissions. The International Energy Agency has projected that about half of the greenhouse gas (GHG) reductions necessary to approach net zero by 2050 will come from technologies that are not yet market ready. Companies in many industries face complex and unclear journeys. Agriculture and food production, transportation and shipping, and energy and power generation, for example, must tackle a trifecta of challenges: high technological and financial hurdles, the threat of significant business disruption, and built-in barriers to big changes. Even for companies with strong C&S commitments and well-tuned innovation engines, the size and the complexity of the task are daunting.

CEOs are on the spot. They must plan for and invest in technologies and solutions whose potential is uncertain and whose development timelines will likely outlast the executives' tenures. There are plenty of risks and no established incentives for success—only growing customer and investor pressure and the need to save the planet. But waiting to see which solutions take shape or which new technologies develop market-ready maturity is not a practical option. Companies that have made net-zero commitments must incorporate solutions based on existing and emerging technologies, starting now. This includes pushing the development and **application of deep technologies**—the problem-driven application of advanced technologies to address large-scale issues.

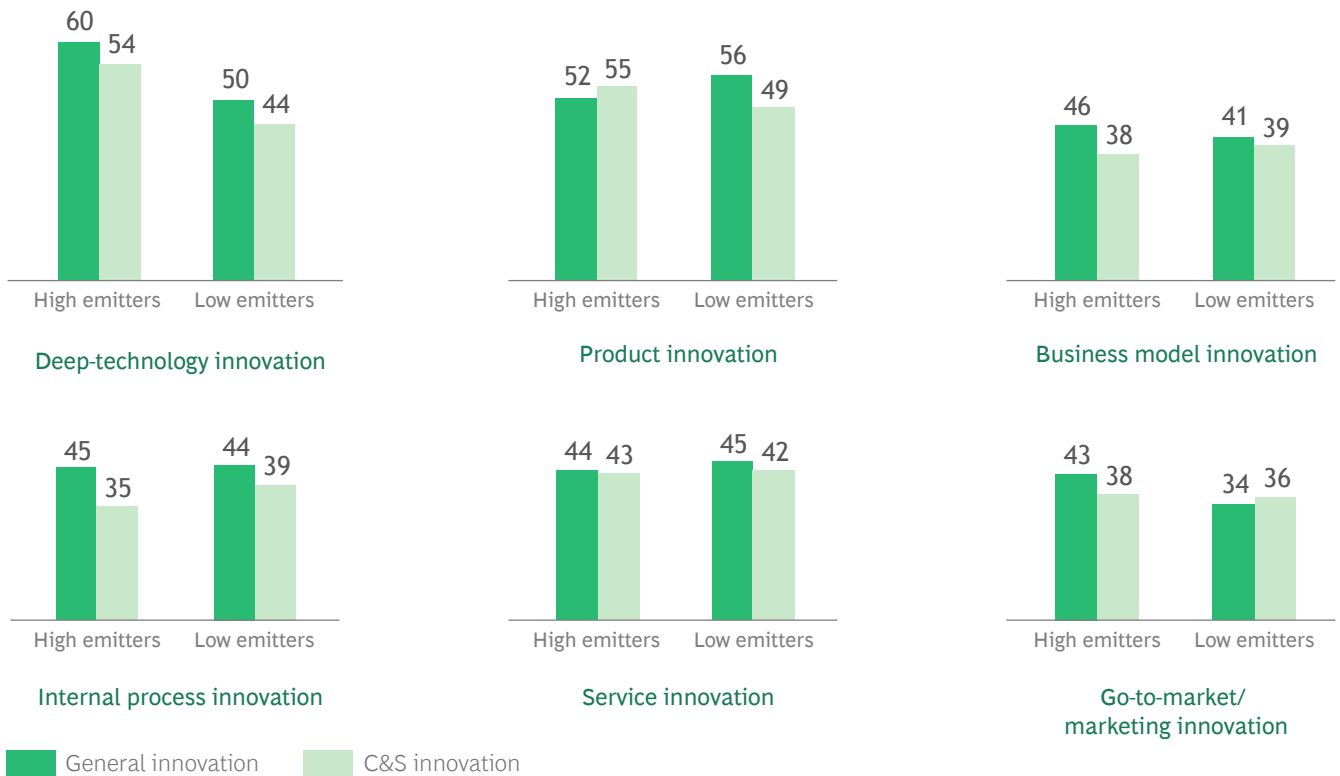


Stewardship and Value

Companies are moving. Our 2022 innovation survey found that 60% of high-emitting companies are targeting deep-tech innovation, and deep tech is the number one or number two innovation focus for these firms. (See Exhibit 9.) In addition, many more committed C&S innovators are leveraging external innovation vehicles that companies typically use for longer-term or more technologically advanced solutions.

Exhibit 9 - High Carbon Emitters Target Deep-Tech Innovations for C&S

Innovations targeted by companies that are also committed C&S innovators (%)



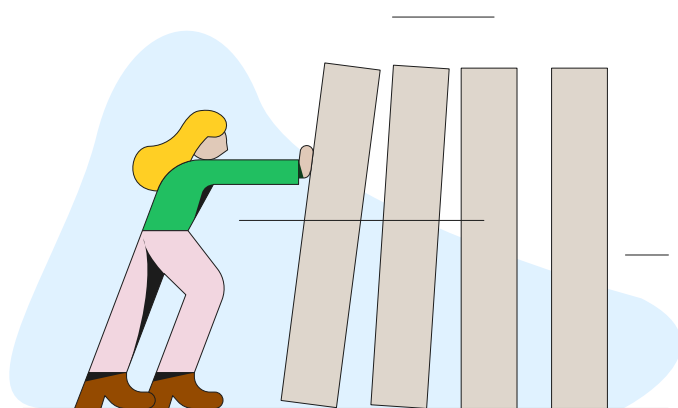
Source: BCG Global Innovation Survey 2022.

Note: Question: “Which of the following types of innovation/R&D/product development are you actively targeting?” “High emitters” are companies that fall in the top quartile for carbon emissions, and “low emitters” are companies that fall in the bottom quartile.

But as we pointed out [earlier in this year's report](#), setting priorities—and even investing behind them—gets you only so far. Leaders also make sure that their innovation engines are ready to act. And their CEOs may need to embrace the idea that on top of their current responsibilities, an element of C&S stewardship is critical, too. Leaders innovate to outperform the competition. C&S stewards take a more comprehensive and longer-term view; they innovate to leave their companies and their industries in better shape than they found them in. They push to raise the performance bar for their sectors as well as for their companies. Going forward, titans of industry will also be stewards of sustainability.

There is an opportunity here. Investors are among those looking for signs of sustainability stewardship. Early movers can not only create value but also change the game by prompting the [systemic changes across sectors](#). Moreover, a financial analysis of market multiples of a US industrial sector conducted for [BCG's 2021 Value Creators Report](#) found a strong inverse correlation between emissions intensity and company valuation. A separate analysis showed that climate leaders achieved higher total shareholder return than laggards did in most sectors.

Correlation does not prove causation, of course, but corporate climate leadership is clearly emerging as a recognized source of competitive advantage. As the battle against climate change intensifies, stewardship may yield even greater rewards. Deep tech provides the leverage. Here's how CEOs can assess their opportunities and calibrate their innovation plans accordingly.



Levels of Ambition

A first step, especially for those aspiring to stewardship, is to assess the extent of the change necessary to make material progress. The effort can range in reach and complexity from relatively straightforward technology substitutions to full-scale systemic transformations. For some types of emissions in some industries, substituting one technological process for another can have a big impact. For example, lighter, stronger, better-insulating materials that require less carbon to produce can lower emissions from buildings, transportation, and the production of materials such as cement, all of which are significant CO₂ emitters.

In the food industry, which is responsible for 26% of current GHG emissions, [alternative proteins](#)—another type of technology substitution—have met with favorable consumer reception. If these proteins continue to make inroads, and if technological advances lead to more and better products, the industry may undergo a disruptive technology upgrade with value pools shifting upstream toward innovations that improve taste, texture, and nutrition.

In mobility, Tesla has built a highly integrated electric vehicle manufacturing company, but the revolution in transportation and mobility that it has sparked now encompasses system-level changes in everything from power sources (batteries) to roadside refueling (charging) to driverless cars.

The Journey to Carbon-Neutral Shipping

Shipping is a high-emitting segment of the transportation sector, accounting for 2% to 3% of global CO₂ emissions as well as for around 80% of world trade. Moreover, because of its role in the supply chains of so many other industries, customers that need to reduce their own scope 2 emissions are looking to shipping to decarbonize.

The Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, a nonprofit commercial foundation, began with seven partners, including shipping giant Mærsk, which has pledged to offer completely carbon-neutral shipping by 2040. The center has assembled a broad ecosystem of players that could contribute to developing solutions. Among the participants are ship builders, engine manufacturers, fuel production and supply companies (both green energy and biomass suppliers and alternative fuel producers), ship owners and operators, and customers. The consortium now has three dozen members.

The center has established clear objectives and a simple timeline for reaching its goal of global climate neutrality for the industry by 2050. (See Exhibit 10.) It is working on a full range of alternative fuel pathways, many of which involve advanced technology and systems-level change in engines and vessel design.

Sectors and Barriers

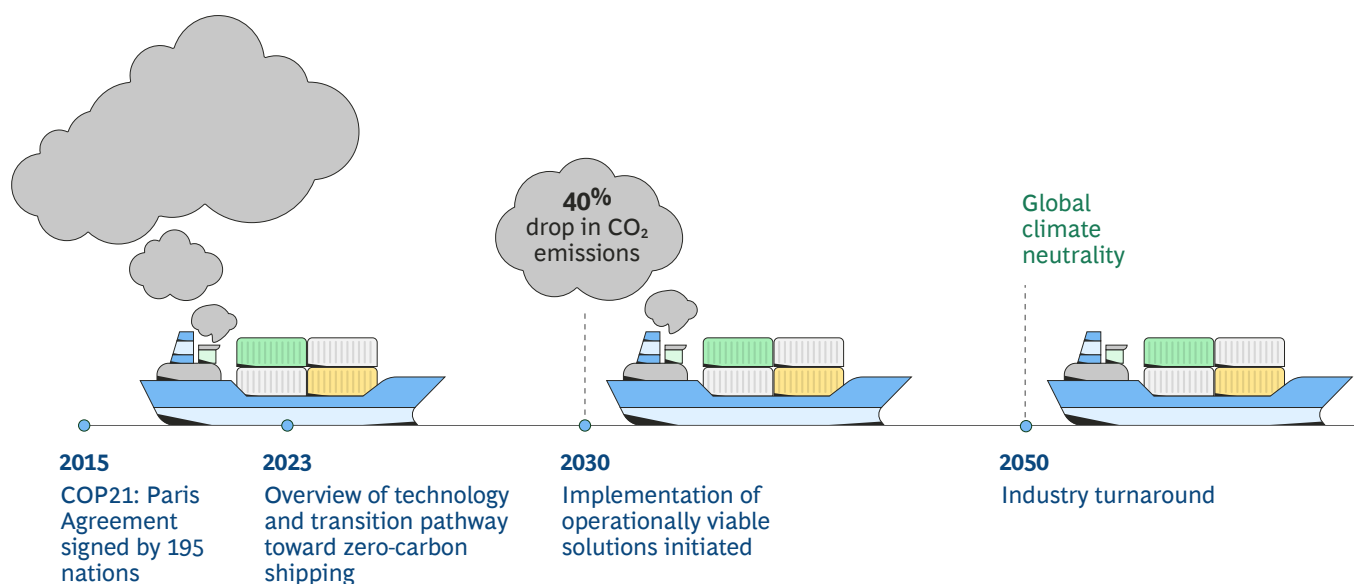
The next step is to assess the **barriers to making material progress** toward net zero. The barriers in each sector differ, although some are common to multiple sectors. Companies can apply various technologies, alone or in combination, to overcome different barriers. (See Exhibit 11.)

Performance and price considerations are a common impediment to change. Unfortunately, existing products and processes in multiple industries require unsustainable energy infrastructure. Current approaches to product and process design in industries such as chemicals, engineering and construction, and energy discourage sustainable practices.

In many sectors, achieving net zero, especially over the last few miles, is likely to require a combination of converging advanced technologies and what energy and climate scholar Arnulf Grübler termed *system-level or system-of-systems (SoS) transformational change*.¹ Although individual companies can do some things on their own to develop and field new climate-friendly products, services, and business models, they cannot tackle the more complex challenges alone. **External vehicles and partnerships** can expand the breadth of what is possible, but broad ecosystems will almost certainly be necessary to provide large-scale access to new technologies and make the economics work.

Exhibit 10 - How the Mærsk Mc-Kinney Møller Center Is Driving the Transformation Toward Zero-Carbon Shipping

Global decarbonization target (IPCC 2018)

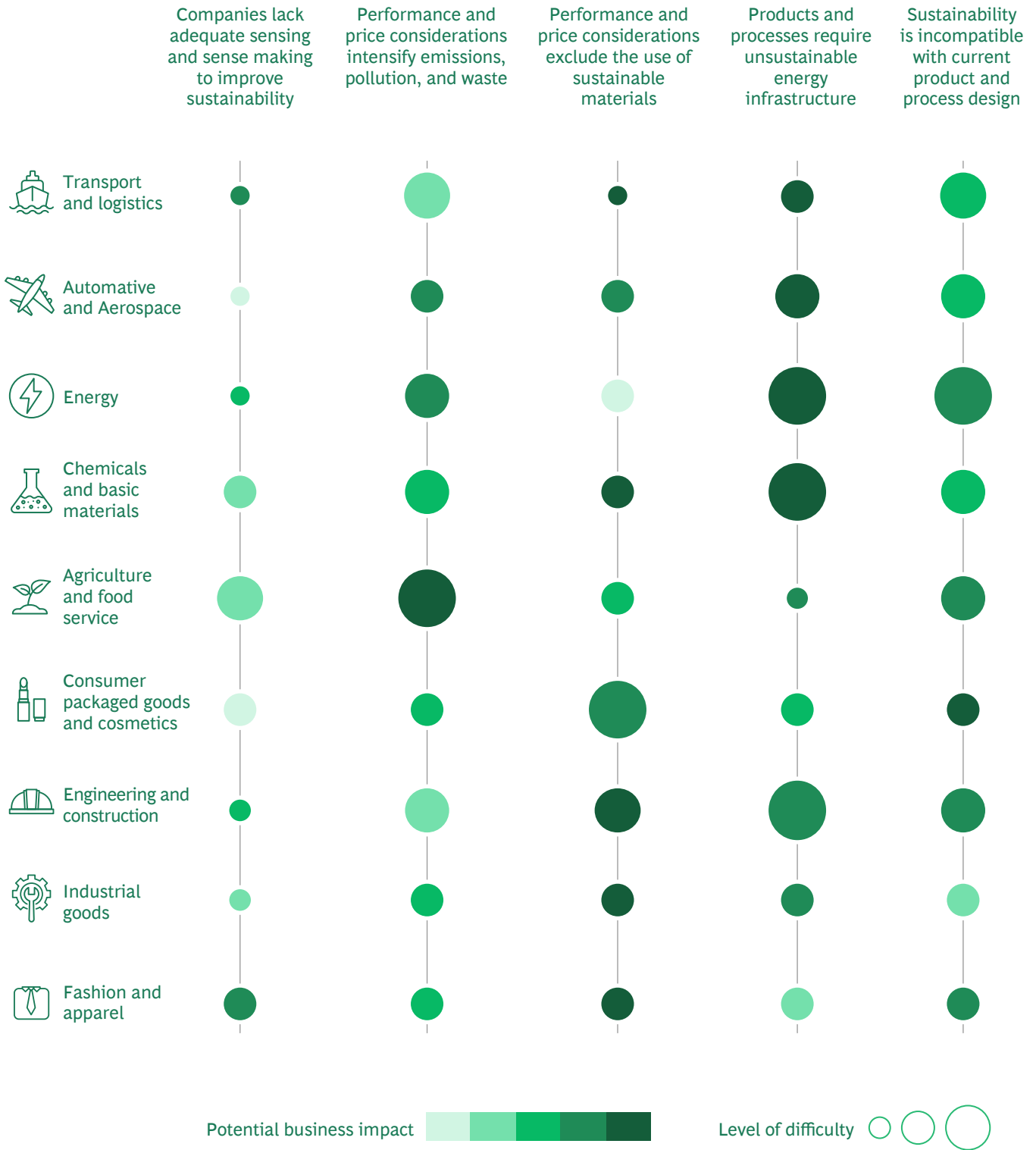


Sources: Publicly available information; BCG experience.

Note: IPCC = Intergovernmental Panel on Climate Change.

1. See, for example, Arnulf Grübler, Charlie Wilson, and Gregory Nemet, "Apples, Oranges, and Consistent Comparisons of the Temporal Dynamics of Energy Transitions," *Energy Research & Social Science* 22 (December 2016): 18–25.

Exhibit 11 - The Key Barriers to Sustainability in Nine Industry Sectors



Sources: UN; IEA; World Resources Institute; OECD and FAO; industry reports; PitchBook; expert interviews; BCG analysis.

Flying at Net Zero

Take the example of aviation. Few industries face a trickier decarbonization innovation challenge. Our analysis indicates that airlines need to take a [portfolio approach and long-term view](#), relying in the near term on technical and operating efficiencies and greater [use of biofuels](#), while looking longer term to new technologies. Since those technologies involve innovations such as battery- and hydrogen-powered planes, SoS-level change is all but inevitable.

Many industry observers expect electric—and in particular, battery-powered—aircraft to be an important, if incomplete, part of the solution. Such planes are best suited to short-haul regional routes, where they can vastly improve not only the emissions picture but the overall economics for carriers. A plethora of startups are at work on new models, and some have order backlogs from major airlines such as United and US regional airline Cape Air. In addition to disrupting aviation, electric aircraft could lead to an unbundling of regional mobility, as the same technology could enable electric vertical takeoff and landing (eVTOL) aircraft, which could displace or augment cars.

To be viable, though, electric aircraft require technological advances in such key components as batteries and strong, lightweight composite materials. They will also need development of a new value chain involving powerplants, batteries, “airport” equivalents, and charging and maintenance regimes, among other pieces. This value chain may coexist with some version on the current value chain, which will evolve toward serving a more long-haul customer base.

Long-haul flights face the most difficult decarbonization challenge. Flights of more than 1,500 kilometers generate 80% of aviation’s CO₂ emissions according to the Air Transport Action Group. These flights have the greatest need for new technologies and, most likely, systemwide change. Enter the Aviation Climate Taskforce (ACT), an industry ecosystem founded by ten global airlines from North America, Europe, and Asia and by BCG (an advisor to many and a big customer of all). ACT’s goal is to accelerate innovation by creating and fostering networks that bring together groups working on similar or related decarbonization technologies. One of its founding principles is that the challenge facing aviation is bigger than any single actor can address, so the sector must collaborate on what amounts to a non-competitive challenge: adopting a more unified approach to accelerate the development of solutions.

ACT will take a portfolio approach and, at the outset, will devote about 70% of its resources to medium-term technologies, such as power-to-liquid synthetic fuels and direct air capture. The overall approach is pragmatic in that it emphasizes the commercial development, market acceptance, and scaling up of solutions as much as the underlying R&D. Because the long-term answers are unclear, the consortium spreads the risk by making more bets than any single member could make on its own. It also aligns incentives: innovations benefit the industry, and companies compete on a level playing field in deciding how to leverage them.

From Leadership to Stewardship

Most CEOs either have innate leadership skills or acquire them over the course of their careers. Stewardship is different and requires some on-the-fly learning. The principles are not complicated, but implementation demands approaches that may not come naturally to many leaders. Here are four tenets that stewards need to adopt:

- **Work back from sustainable futures.** Using a combination of scenario planning, “backcasting,” and systems thinking, analyze how the value chains you participate in need to change to meet net-zero commitments. Which constraints and sources of friction cannot be solved with today’s technologies and approaches?
- **Identify high-leverage technology and business model innovations.** Invest in understanding emerging technologies and their applications through venturing vehicles, such as corporate venture capital and incubators and accelerators. What alternatives to any individual venture, supplier, or partner might open up new options? How might ventures work together through the platforms or at the greater scale that you can provide to achieve synergies?
- **Win together.** Orchestrate or integrate your company into relevant technology ecosystems through partnerships, alliances, and financial commitments. Have you defined mechanisms to pool risk, share upside, and achieve synergies that are achievable only through a value chain transformation?
- **Build a legacy.** Work with your competitors not only to innovate but also to create scale and reach. Leverage government or NGO initiatives to align incentives and metrics. Where might you be able to join forces with your competitors to shape long-term incentives and norms to improve sustainability and grow new markets?

Today, consortia such as those assembled by ACT and the Mærsk Mc-Kinney Møller Center are still more the exception than the rule. But we expect this to change as more companies build out concrete strategies and plans to achieve their net-zero projections. Companies that invest in understanding new technologies and their applications, and orchestrate or integrate themselves into the relevant technology ecosystems, will have a big advantage over their peers. Our research indicates that many are already looking to deep tech for answers. For stewards, the methods used to pursue developing and applying advanced technologies is as important for innovation success as the technologies themselves.



About the Authors

Justin Manly is a managing director and partner in the Chicago office of Boston Consulting Group. You may contact him by email at manly.justin@bcg.com.

Michael Ringel is a managing director and senior partner in the firm's Boston office. You may contact him by email at ringel.michael@bcg.com.

Ramón Baeza is a managing director and senior partner in BCG's Madrid office. You may contact him by email at baeza.ramon@bcg.com.

Will Cornock is partner in the firm's New York office. You may contact him by email at cornock.william@bcg.com.

John Paschkewitz is a partner and associate director in BCG's Washington, DC, office. You may contact him by email at paschkewitz.john@bcg.com.

Amy Hurwitz is a principal in the firm's Los Angeles office. You may contact her by email at hurwitz.amy@bcg.com.

Johann Harnoss is a partner and associate director for innovation in BCG's Berlin office. You may contact him by email at harnoss.johann@bcg.com.

Konstantinos Apostolatos is a managing director and senior partner in the firm's Brussels office. You may contact him by email at apostolatos.konstantinos@bcg.com.

Wendi Backler is a partner and director, innovation analytics and IP, in BCG's Toronto office. You may contact her by email at backler.wendi@bcg.com.

Hubertus Meinecke is a managing director and senior partner in the firm's Berlin office and global leader of the Climate & Sustainability practice. You may contact him by email at meinecke.hubertus@bcg.com.

Lara Koslow is a managing director and senior partner in BCG's Miami office. You may contact her by email at koslow.lara@bcg.com.

Cornelius Pieper is a managing director and senior partner in the firm's Boston office. You may contact him by email at pieper.cornelius@bcg.com.

Stefan Gross-Selbeck is a managing partner of BCG Digital Ventures in Berlin. You may contact him by email at stefan.gross-selbeck@bcgdv.com.

Shalini Unnikrishnan is a managing director and partner in BCG's Chicago office. You may contact her by email at unnikrishnan.shalini@bcg.com.

Rahool Panandiker is a managing director and partner in the firm's Mumbai office. You may contact him by email at panandiker.rahool@bcg.com.

Norihiko Sano is an associate director in BCG's Tokyo office. You may contact him by email at sano.norihiko@bcg.com.

Acknowledgments

The authors are grateful to a number of colleagues for their assistance in the preparation of this report. They include Jon Campos and Andrew Lai for marketing support, Christopher Pommerenke for research support, and Michael Wahlen and Gabriel Wang for analytics.

The authors thank Matthew Clark for his many years of valuable partnership in the development and marketing the Most Innovative Companies series. They also thank the BCG digital, editorial, marketing, and social media teams for their support, particularly Sarah Elliott, Boryana Hintermair, Liz Leykin, Ross Penkala, and Amy Wachler.

For Further Contact

If you would like to discuss this report, please contact the authors.

Methodology

BCG's Most Innovative Companies ranking is based in large part on a survey of more than 1,500 global innovation executives who were polled in December 2021 and January 2022. We assess a company's performance on four dimensions and then take an average of normalized scores to calculate its overall ranking. These four dimensions are:

- **Global Mindshare**—the number of votes received from all global innovation executives
- **Industry Peer View**—the number of votes received from executives in a company's own industry
- **Industry Disruption**—the Diversity Index (Herfindahl-Hirschman) of votes across industries
- **Value Creation**—total shareholder return, including share buybacks from December 31, 2018, through December 31, 2021 (three years)

