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The Next Normal

# Doubling down on sustainability

The other challenge of our times

December 2020

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**The Next Normal**

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# Introduction

Welcome to the “next normal,” the new reality emerging from the ongoing COVID-19 pandemic. How will life, public health, and business continue to change? We’ve chronicled our response in a wide-ranging series of publications—more than 600 articles and counting since the outbreak began.

This volume is the fourth of five edited collections produced to accompany our series airing on CNBC, which examines the forces and themes shaping the next normal. Prior segments and their accompanying collections can be found at [The McKinsey Download Hub](#), on McKinsey.com, where you can also find many of our most recent and popular reports and special collections.

This collection focuses on sustainability, an issue that was rising on the global agenda—only to be cast into the shadows by the pandemic. In a twist, as many forms of travel stopped during the widespread early lockdowns, there were almost immediate environmental benefits. Yet the summer saw record heatwaves, flooding, storms, and wildfires across geographies. It is all too clear that the world cannot afford to ignore climate change and the broader sustainability agenda. Both the pandemic and the climate must be urgent priorities for all leaders.

In these pages, we have collected some of the best recent insights we have published on sustainability: how to stay focused on the long game as the coronavirus demands our short-term attention, how private companies have been working to demonstrate the value of sustainability initiatives to their shareholders, and how the ideal of a circular economy continues to evolve. We have also included articles that have resonated particularly powerfully on McKinsey.com, plus articles authored by Dickon Pinner, global leader of McKinsey’s Sustainability Practice and anchor of the sustainability segment of our CNBC series. We hope you find these insights useful as you continue to navigate your way into the evolving next normal.

In the coming few months, we will publish one more collection and segment on CNBC, on resilience. You can download this and other collections in this series as they become available at [McKinsey.com/thenextnormal](#), where you will also find our entire collection of coronavirus-related insights.

**Raju Narisetti**

Publisher

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# Contents

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## Staying focused in the face of a pandemic

- 6 Addressing climate change in a post-pandemic world
- 12 Climate math: What a 1.5-degree pathway would take
- 30 How a post-pandemic stimulus can both create jobs and help the climate
- 40 Water: A human and business priority

---

## Measuring the business value

- 48 The ESG premium: New perspectives on value and performance
- 56 Earth to CEO: Your company is already at risk from climate change
- 60 More than values: The value-based sustainability reporting that investors want

---

## Getting circular

- 70 Mapping the benefits of a circular economy
- 76 Toward a circular economy in food

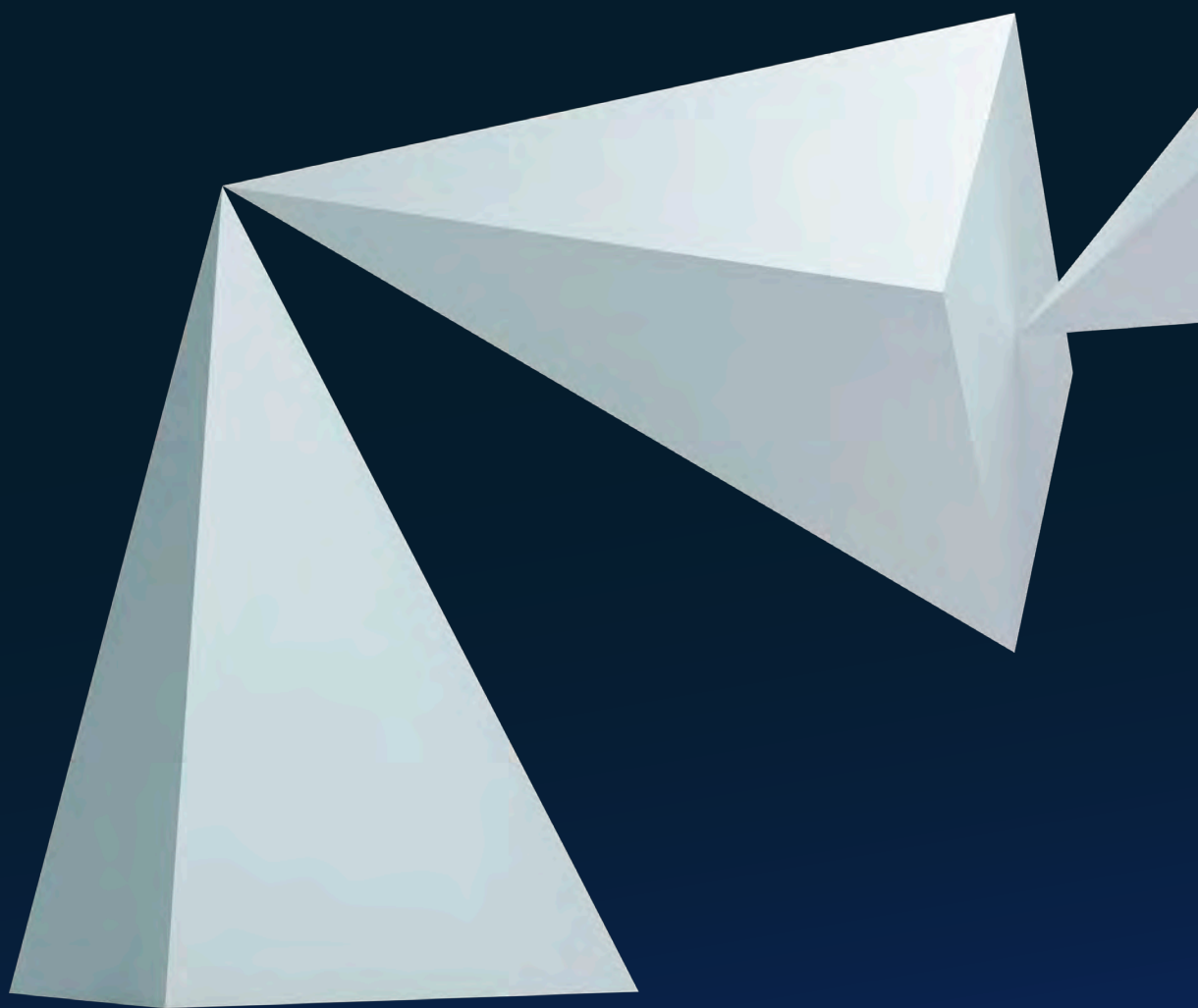
### Articles by Dickon Pinner

- 82 Reduced dividends on natural capital?
- 90 Reimagining mobility: A CEO's guide
- 100 How solar energy can (finally) create value
- 106 Brave new world: Myths and realities of clean technologies

---

## Recently on McKinsey.com

- 112 Biodiversity: The next frontier in sustainable fashion
- 120 Ørsted's renewable-energy transformation
- 126 How airlines can chart a path to zero-carbon flying
- 136 Climate risk and decarbonization: What every mining CEO needs to know
- 148 Charging electric-vehicle fleets: How to seize the emerging opportunity





**6**

Addressing climate change  
in a post-pandemic world

**12**

Climate math: What a  
1.5-degree pathway  
would take

**30**

How a post-pandemic  
stimulus can both create  
jobs and help the climate

**40**

Water: A human and  
business priority

# Staying focused in the face of a pandemic



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# Addressing climate change in a post-pandemic world

The coronavirus crisis holds profound lessons that can help us address climate change—if we make greater economic and environmental resiliency core to our planning for the recovery ahead.

*by Dickon Pinner, Matt Rogers, and Hamid Samandari*

**A ferocious pandemic** is sweeping the globe, threatening lives and livelihoods at an alarming rate. As infection and death rates continue to rise, resident movement is restricted, economic activity is curtailed, governments resort to extraordinary measures, and individuals and corporations scramble to adjust. In the blink of an eye, the coronavirus has upended the world's operating assumptions. Now, all attention is focused on countering this new and extreme threat, and on blunting the force of the major recession that is likely to follow.

Amid this dislocation, it is easy to forget that just a few short months ago, the debate about climate change, the socioeconomic impacts it gives rise to, and the collective response it calls for were gaining momentum. Sustainability, indeed, was rising on the agenda of many public- and private-sector leaders—before the unsustainable, suddenly, became impossible to avoid.

Given the scope and magnitude of this sudden crisis, and the long shadow it will cast, can the world afford to pay attention to climate change and the broader sustainability agenda at this time? Our firm belief is that we simply cannot afford to do otherwise. Not only does climate action remain critical over the next decade, but investments in climate-resilient infrastructure and the transition to a lower-carbon future can drive significant near-term job creation while increasing economic and environmental resiliency. And with near-zero interest rates for the foreseeable future, there is no better time than the present for such investments.

To meet this need and to leverage this opportunity, we believe that leaders would benefit from considering three questions:

- What lessons can be learned from the current pandemic for climate change?
- What implications—positive or negative—could our pandemic responses hold for climate action?
- What steps could companies, governments, and individuals take to align our immediate pandemic response with the imperatives of sustainability?

What follows is our attempt at providing some initial answers to these questions, in the hope that they will inspire ideas and actions that help connect our immediate crisis response with priorities for recovery.

## Potential lessons from the current pandemic

Understanding the similarities, the differences, and the broader relationships between pandemics and climate risk is a critical first step if we are to derive practical implications that inform our actions.

### Fundamental similarities

Pandemics and climate risk are similar in that they both represent physical shocks, which then translate into an array of socioeconomic impacts. By contrast, financial shocks—whether bank runs, bubble bursts, market crashes, sovereign defaults, or currency devaluations—are largely driven by human sentiment, most often a fear of lost value or liquidity. Financial shocks originate from within the financial system and are frequently remedied by restoring confidence. Physical shocks, however, can only be remedied by understanding and addressing the underlying physical causes. Our recent collective experience, whether in the public or the private sector, has been more often shaped by financial shocks, not physical ones. The current pandemic provides us perhaps with a foretaste of what a full-fledged climate crisis could entail in terms of simultaneous exogenous shocks to supply and demand, disruption of supply chains, and global transmission and amplification mechanisms.

Pandemics and climate risk also share many of the same attributes. Both are *systemic*, in that their direct manifestations and their knock-on effects propagate fast across an interconnected world. Thus, the oil-demand reduction in the wake of the initial coronavirus outbreak became a contributing factor to a price war, which further exacerbated the stock market decline as the pandemic grew. They are both *nonstationary*, in that past probabilities and distributions of occurrences are rapidly shifting and proving to be inadequate or insufficient for future projections. Both are *nonlinear*, in that their socioeconomic impact grows disproportionately and even catastrophically once certain thresholds

are breached (such as hospital capacity to treat pandemic patients). They are both *risk multipliers*, in that they highlight and exacerbate hitherto untested vulnerabilities inherent in the financial and healthcare systems and the real economy. Both are *regressive*, in that they affect disproportionately the most vulnerable populations and subpopulations of the world. Finally, neither can be considered as a “black swan,” insofar as experts have consistently warned against both over the years (even though one may argue that the debate about climate risk has been more widespread). And the coronavirus outbreak seems to indicate that the world at large is equally ill prepared to prevent or confront either.

Furthermore, addressing pandemics and climate risk requires the same fundamental shift, from optimizing largely for the *shorter-term performance* of systems to ensuring equally their *longer-term resiliency*. Healthcare systems, physical assets, infrastructure services, supply chains, and cities have all been largely designed to function within a very narrow band of conditions. In many cases, they are already struggling to function within this band, let alone beyond it. The coronavirus pandemic and the responses that are being implemented (to the tune of several trillion dollars of government stimulus as of this writing) illustrate how expensive the failure to build resiliency can ultimately prove. In climate change as in pandemics, the costs of a global crisis are bound to vastly exceed those of its prevention.

Finally, both reflect “tragedy of the commons” problems, in that individual actions can run counter to the collective good and deplete a precious, common resource. Neither pandemics nor climate hazards can be confronted without true *global coordination and cooperation*. Indeed, despite current indications to the contrary, they may well prove, through their accumulated pressures, that boundaries between one nation and another are much less important than boundaries between problems and solutions.

#### Key differences

While the similarities are significant, there are also some notable differences between pandemics and climate hazards.

A global public-health crisis presents *imminent, discrete, and directly discernable dangers*, which we have been conditioned to respond to for our survival. The risks from climate change, by contrast, are *gradual, cumulative, and often distributed dangers* that manifest themselves in degrees and over time. They also require a present action for a future reward that has in the past appeared too uncertain and too small given the implicit “discount rate.” This is what former Bank of England Governor Mark Carney has called the “tragedy of the horizon.”<sup>1</sup>

Another way of saying this is that the *timescales* of both the occurrence and the resolution of pandemics and climate hazards are different. The former are

**Neither pandemics nor climate hazards can be confronted without true global coordination and cooperation.**



often measured in weeks, months, and years; the latter are measured in years, decades, and centuries. What this means is that a global climate crisis, if and when ushered in, could prove far lengthier and far more disruptive than what we currently see with the coronavirus (if that can be imagined).

Finally, pandemics are a case of *contagion* risk, while climate hazards present a case of *accumulation* risk. Contagion can produce perfectly correlated events on a global scale (even as we now witness), which can tax the entire system at once; accumulation gives rise to an increased likelihood of severe, contemporaneous but not directly correlated events that can reinforce one another. This has clear implications for the mitigation actions they each call for.

### **Broader relationships**

Climate change—a potent risk multiplier—can actually contribute to pandemics, according to researchers at Stanford University and elsewhere.<sup>2</sup> For example, rising temperatures can create favorable conditions for the spread of certain infectious, mosquito-borne diseases, such as malaria and dengue fever, while disappearing habitats may force various animal species to migrate, increasing the chances of spillover pathogens between them. Conversely, the same factors that mitigate environmental risks—reducing the demands we place on nature by optimizing consumption, shortening and localizing supply chains, substituting animal proteins with plant proteins, decreasing pollution—are likely to help mitigate the risk of pandemics.

The environmental impact of some of the measures taken to counter the coronavirus pandemic have been seen by some as a full-scale illustration of what drastic action can produce in a short amount of time. Satellite images of vanishing pollution in

China and India during the COVID-19 lockdown are a case in point. Yet this (temporary) impact comes at tremendous human and economic cost. The key question is how to find a paradigm that provides at once environmental and economic sustainability. Much more easily said than done, but still a must-do.

## **What could happen now?**

While we are at the initial stages of a fast-unfolding crisis, we can already start seeing how the pandemic may influence the pace and nature of climate action, and how climate action could accelerate the recovery by creating jobs, driving capital formation, and increasing economic resiliency.

### **Factors that could support and accelerate climate action**

For starters, certain temporary adjustments, such as teleworking and greater reliance on digital channels, may endure long after the lockdowns have ended, reducing transportation demand and emissions. Second, supply chains may be repatriated, reducing some Scope 3 emissions (those in a company's value chain but not associated with its direct emissions or the generation of energy it purchases). Third, markets may better price in risks (and, in particular, climate risk) as the result of a greater appreciation for physical and systemic dislocations. This would create the potential for additional near-term business-model disruptions and broader transition risks but also offer greater incentives for accelerated change.

There may, additionally, be an increased public appreciation for scientific expertise in addressing systemic issues. And, while not a foregone conclusion, there may also be a greater appetite for the preventive and coordinating role of governments in tackling such risks. Indeed, the tremendous costs of being the payor, lender, and insurer of last resort may prompt governments to take a much more

<sup>1</sup> "Breaking the tragedy of the horizon—climate change and financial stability—speech by Mark Carney," Bank of England, September 29, 2015, [bankofengland.co.uk](https://www.bankofengland.co.uk/speeches/2015/0929).

<sup>2</sup> See Andrew Winston, "Is the COVID-19 outbreak a black swan or the new normal?," *MIT Sloan Management review*, March 16, 2020; and Rob Jordan, "How does climate change affect disease?," *Stanford Earth, School of Earth, Energy & Environment*, March 15, 2019.

active role in ensuring resiliency. As for the private sector, the tide may be turning toward “building back better” after the crisis.<sup>3</sup>

Moreover, lower interest rates may accelerate the deployment of new sustainable infrastructure, as well as of adaptation and resilience infrastructure—investments that would support near-term job creation. And lastly, the need for global cooperation may become more visible and be embraced more universally.

If past is prologue, both the probability of such shifts and their permanence are likely to be proportional to the depth of the current crisis itself.

### **Factors that may hamper and delay climate action**

Simultaneously, though, very low prices for high-carbon emitters could increase their use and further delay energy transitions (even though lower oil prices could push out a number of inefficient, high-emission, marginal producers and encourage governments to end expensive fuel-subsidy regimes). A second crosscurrent is that governments and citizens may struggle to integrate climate priorities with pressing economic needs in a recovery. This could affect their investments, commitments, and regulatory approaches—potentially for several years, depending on the depth of the crisis and hence the length of the recovery. Third, investors may delay their capital allocation to new lower-carbon solutions due to decreased wealth. Finally, national rivalries may be exacerbated if a zero-sum-game mentality prevails in the wake of the crisis.

### **What should be done?**

In this context, we believe all actors—individuals, companies, governments, and civil society—will have an important role.

For governments, we believe four sets of actions will be important. First, build the capability to model climate risk and to assess the economics of climate change. This would help inform recovery programs, update and enhance historical models that are

used for infrastructure planning, and enable the use of climate stress testing in funding programs. Second, devote a portion of the vast resources deployed for economic recovery to climate-change resiliency and mitigation. These would include investments in a broad range of sustainability levers, including building renewable-energy infrastructure, expanding the capacity of the power grid and increasing its resiliency to support increased electrification, retrofitting buildings, and developing and deploying technologies to decarbonize heavy industries. The returns on such investments encompass both risk reduction and new sources of growth. Third, seize the opportunity to reconsider existing subsidy regimes that accelerate climate change. Fourth, reinforce national and international *alignment and collaboration* on sustainability, for inward-looking, piecemeal responses are by nature incapable of solving systemic and global problems. Our experiences in the weeks and months ahead could help inform new paths toward achieving alignment on climate change.

For companies, we see two priorities. First, seize the moment to decarbonize, in particular by prioritizing the retirement of economically marginal, carbon-intensive assets. Second, take a systematic and through-the-cycle approach to building resilience. Companies have fresh opportunities to make their operations more resilient and more sustainable as they experiment out of necessity—for example, with shorter supply chains, higher-energy-efficiency manufacturing and processing, videoconferencing instead of business travel, and increased digitization of sales and marketing. Some of these practices could be expedient and economical to continue, and might become important components of a company-level sustainability transformation—one that accompanies the cost-efficiency and digital-transformation efforts that are likely to be undertaken across various industries in the wake of the pandemic.

When it comes to resilience, a major priority is building the capability to truly understand,

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<sup>3</sup>María Mendiluce, “How to build back better after COVID-19,” World Economic Forum, April 3, 2020, [weforum.org](https://www.weforum.org).

qualitatively and quantitatively, corporate vulnerabilities against a much broader set of scenarios, and particularly physical events. In that context, it will also be important to model and prepare for situations where multiple hazards would combine: it is indeed not difficult to imagine a pandemic resurgence coinciding with floods or fires in a given region, with significant implications for disaster response and recovery. The same holds true for public entities, where resilience thinking will have to take greater account of the combination and correlation of events.

For all—individuals, companies, governments, and civil society—we see two additional priorities. First, use this moment to raise awareness of the impact of a climate crisis, which could ultimately create disruptions of great magnitude and duration. That includes awareness of the fact that physical shocks can have massive nonlinear impacts on financial and economic systems and thus prove extremely costly. Second, build upon the *mindset and behavioral*

*shifts* that are likely to persist after the crisis (such as working from home) to reduce the demands we place on our environment—or, more precisely, to shift them toward more sustainable sources.

By all accounts, the steps we take in the decade ahead will be crucial in determining whether we avoid runaway climate change. An average global temperature rise above 1.5 or 2°C would create risks that the global economy is not prepared to weather. At an emission rate of 40 to 50 gigatons of CO<sub>2</sub> per year, the global economy has ten to 25 years of carbon capacity left. Moving toward a lower-carbon economy presents a daunting challenge, and, if we choose to ignore the issue for a year or two, the math becomes even more daunting. In short, while all hands must be on deck to defeat the coronavirus and to restart the economy, to save lives and livelihoods, it is also critical that we begin now to integrate the thinking and planning required to build a much greater economic and environmental resiliency as part of the recovery ahead.

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# Climate math: What a 1.5-degree pathway would take

Decarbonizing global business at scale is achievable, but the math is daunting.

**Amid the coronavirus pandemic**, everyone is rightly focused on protecting lives and livelihoods. Can we simultaneously strive to avoid the next crisis? The answer is yes—if we make greater environmental resilience core to our planning for the recovery ahead, by focusing on the economic and employment opportunities associated with investing in both climate-resilient infrastructure and the transition to a lower-carbon future.

Adapting to climate change is critical because, as a recent McKinsey Global Institute report shows, with further warming unavoidable over the next decade, the risk of physical hazards and nonlinear, socioeconomic jolts is rising.<sup>1</sup> Mitigating climate change through decarbonization represents the other half of the challenge. Scientists estimate that limiting warming to 1.5 degrees Celsius would reduce the odds of initiating the most dangerous and irreversible effects of climate change.

While a number of analytic perspectives explain how greenhouse-gas (GHG) emissions would need to evolve to achieve a 1.5-degree pathway, few paint a clear and comprehensive picture of the actions global business could take to get there. And little wonder: the range of variables and their complex interaction make any modeling difficult. As part of an ongoing research effort, we sought to cut through the complexity by examining, analytically,

the degree of change that would be required in each sector of the global economy to reach a 1.5-degree pathway. What technically feasible carbon-mitigation opportunities—in what combinations and to what degree—could potentially get us there?

We also assessed, with the help of McKinsey experts in multiple industrial sectors, critical stress points—such as the pace of vehicle electrification and the speed with which the global power mix shifts to cleaner sources. We then built a set of scenarios intended to show the trade-offs: If one transition (such as the rise of renewables) lags, what compensating shifts (such as increased reforestation) would be necessary to get to a 1.5-degree pathway?

The good news is that a 1.5-degree pathway is technically achievable. The bad news is that the math is daunting. Such a pathway would require dramatic emissions reductions over the next ten years—starting now. This article seeks to translate the output of our analytic investigation into a set of discrete business and economic variables. Our intent is to clarify a series of prominent shifts—encompassing food and forestry, large-scale electrification, industrial adaptation, clean-power generation, and carbon management and markets—that would need to happen for the world to move rapidly onto a 1.5-degree pathway.

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<sup>1</sup> See "Climate risk and response: Physical hazards and socioeconomic impacts," McKinsey Global Institute, January 2020, McKinsey.com.

## About this article

This article was a collaboration between **Kimberly Henderson** (partner in McKinsey's Washington, DC, office and leader of the research effort underpinning this article), **Dickon Pinner** (senior partner in the San Francisco office and global leader of McKinsey's Sustainability Practice), **Matt Rogers**

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None of what follows is a forecast. Getting to 1.5 degrees would require significant economic incentives for companies to invest rapidly and at scale in decarbonization efforts. It also would require individuals to make changes in areas as fundamental as the food they eat and their modes of transport. A markedly different regulatory environment would likely be necessary to support the required capital formation. Our analysis, therefore, presents a picture of a world that could be, a clear-eyed reality check on how far we are from achieving it, and a road map to help business leaders and policy makers better understand, and navigate, the challenges and choices ahead.

## Understanding the challenge

While it might seem intuitive, it's worth emphasizing at the outset: every part of the economy would need to

decarbonize to achieve a 1.5-degree pathway. Should any source of emissions delay action, others would need to compensate through further GHG reductions to have any shot at meeting a 1.5-degree standard.

### No easy answers

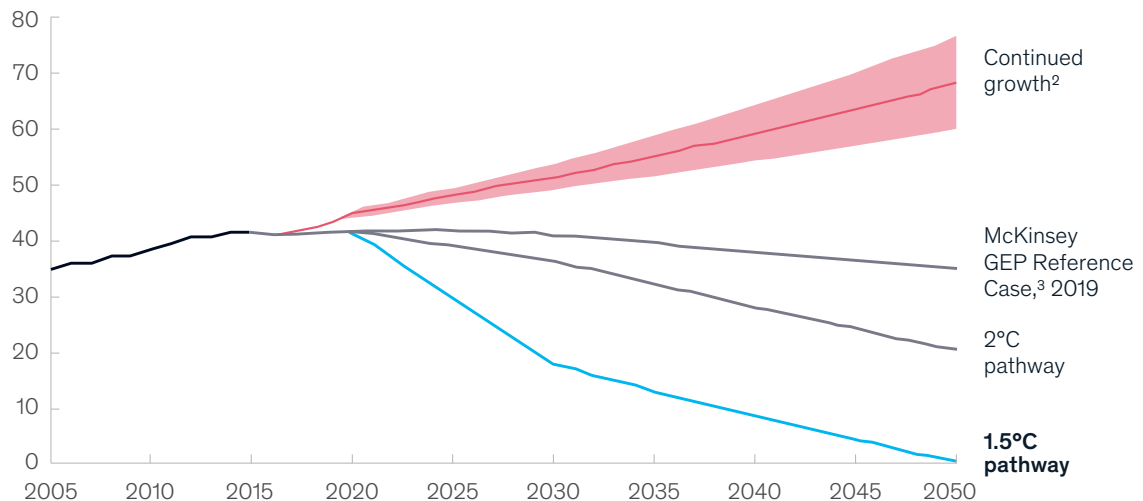
And the stark reality is that delay is quite possible. McKinsey's Global Energy Perspective 2019: Reference Case, for example, which depicts what the world energy system might look like through 2050 based on current trends, is among the most aggressive such outlooks on the potential for renewable energy and electric-vehicle (EV) adoption. Yet even as the report predicts a peak in global demand for oil in 2033 and substantial declines in CO<sub>2</sub> emissions, it notes that a "1.5-degree or even a 2-degree scenario remains far away" (Exhibit 1). Similarly, the McKinsey Center for Future Mobility (MCFM)—which foresees a

Exhibit 1

## Rapid declines in CO<sub>2</sub> emissions would be required to reach a 1.5°C pathway.

Projected global CO<sub>2</sub> emissions per scenario<sup>1</sup>

Metric gigatons of CO<sub>2</sub> (GtCO<sub>2</sub>) per year



<sup>1</sup> In addition to energy-related CO<sub>2</sub> emissions, all pathways include industry-process emissions (eg, from cement production), emissions from deforestation and waste, and negative emissions (eg, from reforestation and carbon-removal technologies such as bioenergy with carbon capture and storage, or BECCS, and direct air carbon capture and storage, or DACCS). Conversely, emissions from biotic feedbacks (eg, from permafrost thawing, wildfires) are not included.

<sup>2</sup> Lower bound for "continued growth" pathway is akin to IEA's *World Energy Outlook 2019* Current Policies Scenario; higher bound based on IPCC's Representative Concentration Pathway 8.5.

<sup>3</sup> GEP = Global Energy Perspective; reference case factors in potential adoption of renewable energy and electric vehicles.

Source: Global Carbon Budget 2019; *World Energy Outlook 2019*, IEA, expanded by Woods Hole Research Center; McKinsey *Global Energy Perspective 2019: Reference Case*; McKinsey 1.5°C scenario analysis



dramatic inflection point for transportation<sup>2</sup>—does not envision EV penetration hitting the levels that our analysis finds would be needed by 2030 to achieve a 1.5-degree pathway. MCFM analysis also underscores a related challenge: the need to take a “well to wheel” perspective that accounts for not only the power source of the vehicles but also how sustainably that power is generated or produced.

Given such uncertainties and interdependencies, we created three potential 1.5-degree-pathway scenarios. This allowed us to account for flexibility in the pace of decarbonization among some of

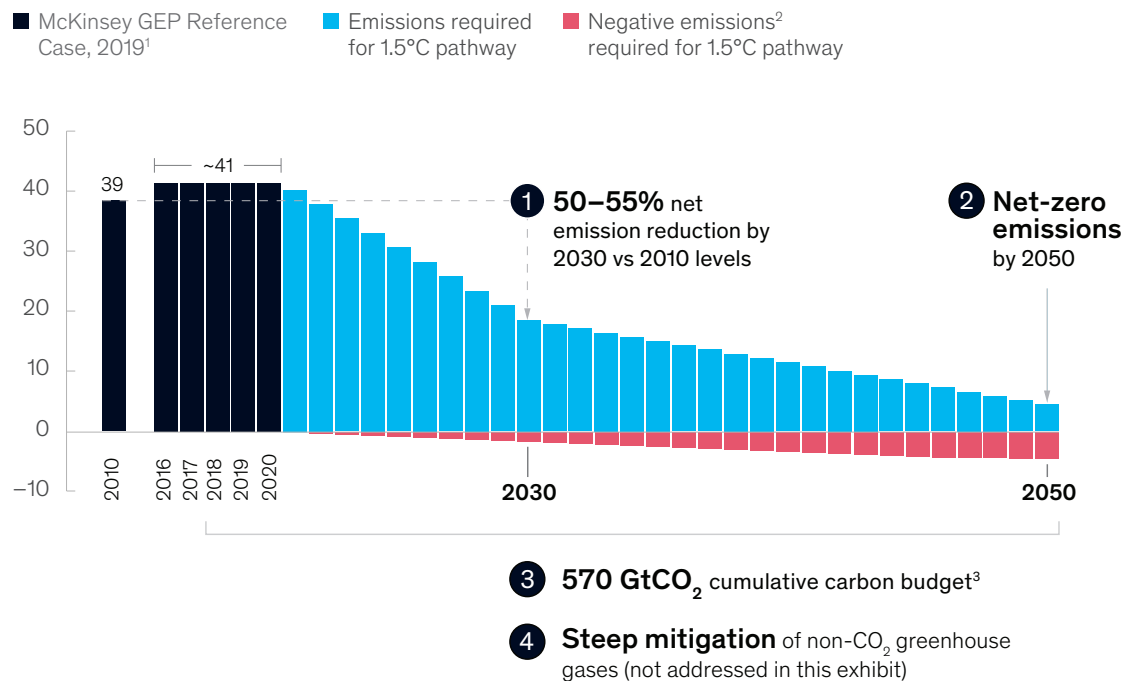
the largest sources of GHGs (for example, power generation and transportation) without being predictive (see sidebar “About the research”). All the scenarios, we found, would imply the need for immediate, all-hands-on-deck efforts to dramatically reduce GHG emissions. The first scenario frames deep, sweeping emission reductions across all sectors; the second assumes oil and other fossil fuels remain predominant in transport for longer, with aggressive reforestation absorbing the surplus emissions; and the third scenario assumes that coal and gas continue to generate power for longer, with even more vigorous

<sup>2</sup>See Rajat Dhawan, Russell Hensley, Asutosh Padhi, and Andreas Tschiesner, “Mobility’s second great inflection point,” *McKinsey Quarterly*, February 2019, McKinsey.com.

## Exhibit 2

### A paced transition to a 1.5°C pathway has four requirements.

Cumulative global CO<sub>2</sub> emissions, current and historical, metric gigatons of CO<sub>2</sub> (GtCO<sub>2</sub>) per year



<sup>1</sup>GEP = Global Energy Perspective reference case.

<sup>2</sup>Achieved, for example, from reforestation and carbon-removal technologies such as bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS).

<sup>3</sup>Budget of 570 GtCO<sub>2</sub> emissions from 2018 onward offers a 66% chance of limiting global warming to 1.5°C, when assessing historical temperature increases from a blend of air and sea-surface temperatures.

Source: Corinne Le Quéré et al., Global Carbon Budget 2018, *Earth Systems Science Data*, 2018, Volume 10, Number 4; IPCC; McKinsey *Global Energy Perspective 2019: Reference Case*; McKinsey 1.5°C scenario analysis

## About the research

This article's foundation is a bottom-up, sector-by-sector assessment of greenhouse-gas emissions and abatement potential. Starting with the status quo for each source of emissions (exhibit), we reviewed with McKinsey colleagues and select external experts the technically feasible emission-reduction levers over different time horizons. It was immediately clear that a 1.5-degree pathway would be unreachable if all investments modeled must deliver positive economic returns (and many likely won't, given that the

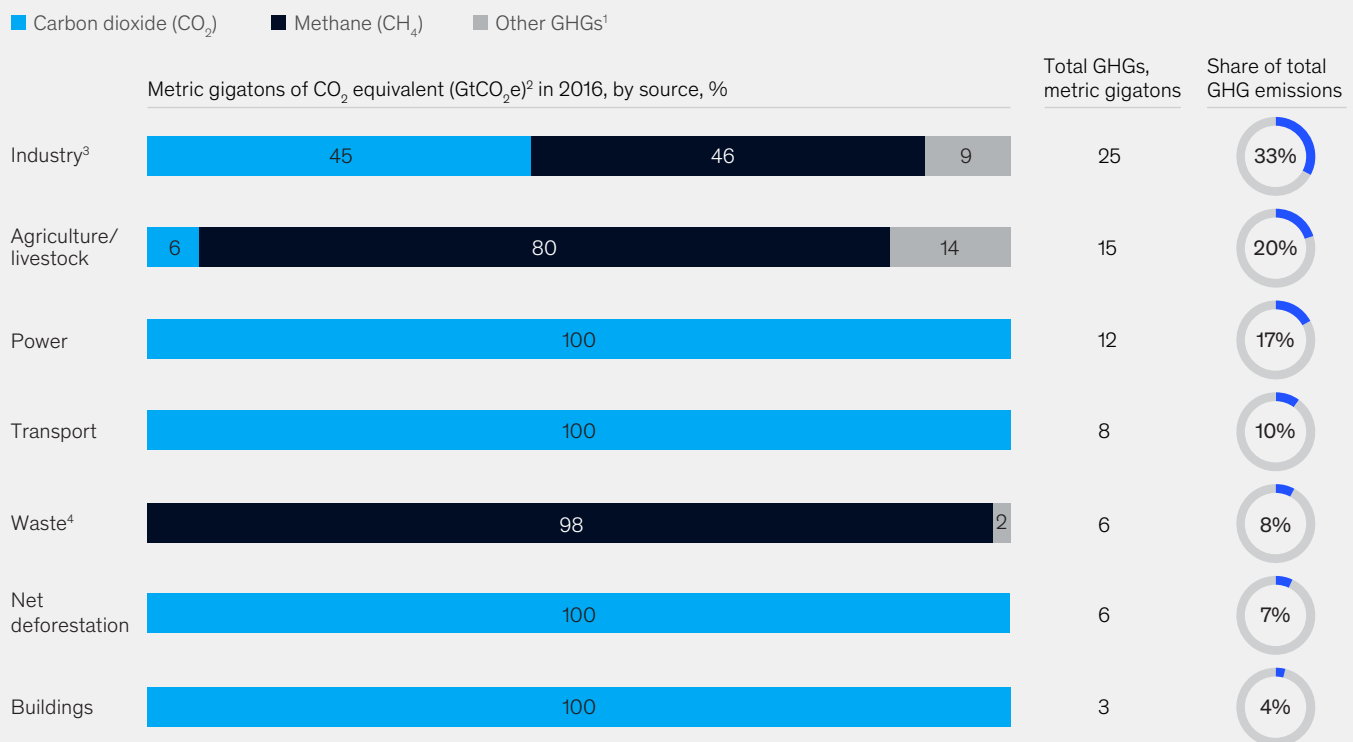
externalities of emissions and related climate effects are not fully priced in). We therefore relaxed this assumption, which implies the need for regulatory incentives to account for challenging abatement opportunities.

To create 1.5-degree-pathway scenarios, we established a binding constraint based on forecasts from the Intergovernmental Panel on Climate Change (IPCC): a remaining carbon budget of 570 gigatons (Gt) for CO<sub>2</sub> as of January 1, 2018, and a complementary reduction of non-CO<sub>2</sub>

gases to tackle the warming effects of methane and nitrous oxide. An infinite set of permutations could, theoretically, enable the global economy to remain within these parameters. But constraints such as the time it takes for emerging technologies to achieve meaningful penetration, along with politics and regional barriers, reduce the degrees of freedom. As shown in the accompanying scenario descriptions, the three future states depicted here incorporate different variations on such barriers to implementation.

### Exhibit

## Anthropogenic greenhouse-gas (GHG) emissions per sector and type of gas



<sup>1</sup>Includes emissions from hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride.

<sup>2</sup>Non-CO<sub>2</sub> emissions converted into CO<sub>2</sub>e using 20-year global-warming-potential values from IPCC Assessment Report 5.

<sup>3</sup>Includes cement, chemical production, iron and steel, mining, oil and gas, and low- to medium-temperature and high-temperature industries, among others.

<sup>4</sup>Includes food waste, biological treatment of solid waste, incineration and open burning of waste, solid-waste disposal, and wastewater treatment and discharge.

Source: Emissions Database for Global Atmospheric Research (EDGAR), 2015; FAOSTAT, 2015; IEA, 2015; McKinsey *Global Energy Perspective 2019: Reference Case*; McKinsey 1.5°C scenario analysis

reforestation making up the deficit (see “Three paths to 1.5°C,” on page 23).

### Urgency amid uncertainty

These scenarios represent rigorous, data-driven snapshots of the decarbonization challenge, not predictions; reality may play out quite differently. Still, the implied trade-offs underscore just how stark a departure a 1.5-degree pathway is from the global economy’s current trajectory. Keeping to 1.5 degrees would require limiting all future net emissions of carbon dioxide from 2018 onward to 570 gigatons (Gt),<sup>3</sup> and reaching net-zero emissions by 2050 (Exhibit 2). How big a hill is this to climb? At the current pace, the world would exceed the 570-Gt target in 2031. Although an “overshoot” of the 570-Gt carbon budget is common in many analyses, we have avoided it in these scenarios: the impact of an overshoot in temperature, and thus in triggering climate feedbacks, as well as the effectiveness of negative emissions at decreasing temperatures, are unknown—multiplying the uncertainties in any such scenarios.

And CO<sub>2</sub> is just part of the picture. Although as much as 75 percent of the observed warming since 1850 is attributable to carbon dioxide,<sup>4</sup> the remaining warming is linked to other GHGs such as methane and nitrous oxide. Methane, in fact, is 86 times more potent than CO<sub>2</sub> in driving temperature increases over a 20-year time frame,<sup>5</sup> though it persists in the atmosphere for much less time. Our analysis, therefore, encompassed all three major greenhouse gases: carbon dioxide, methane, and nitrous oxide. Our scenarios imply achieving a reduction of more than 50 percent in net CO<sub>2</sub> by 2030 (relative to 2010 levels)<sup>6</sup> and a reduction of other greenhouse gases by roughly 40 percent over that time frame.

The implication of all this is that reaching a 1.5-degree pathway would require rapid action. Our scenarios reflect a world in which the steepest emission declines would need to happen over the next decade. Without global, comprehensive, and near-term action, a 1.5-degree pathway is likely out of reach.

Regardless of the scenario, five major business, economic, and societal shifts would underlie a transition to a 1.5-degree pathway. Each shift would be enormous in its own right, and their interdependencies would be intricate. That makes an understanding of these trade-offs critical for business leaders, who probably will be participating in some more than others but are likely to experience all five.

### Shift 1: Reforming food and forestry

Although the start of human-made climate change is commonly dated to the Industrial Revolution, confronting it successfully would require taking a hard look at everything, including fundamentals such as the trees that cover the earth, as well as the food we eat and the systems that grow and supply it.

#### Changing what we eat, how it’s farmed, and how much we waste

The world’s food and agricultural systems are enormously productive, thanks in no small part to the Green Revolution that, starting in the 1960s, boosted yields through mechanization, fertilization, and high-yielding crop varieties. However, modern agricultural practices have depleted CO<sub>2</sub> in the soil, and, even though some CO<sub>2</sub> is absorbed by crops and plants, agriculture remains a net emitter of CO<sub>2</sub>. Moreover, agricultural and food systems generate the potent

<sup>3</sup>Our analysis draws on the work of the Intergovernmental Panel on Climate Change (IPCC) by using a remaining carbon budget of 570 metric gigatons (Gt) CO<sub>2</sub> as of January 1, 2018. Remaining within this budget would equate to a 66 percent chance of limiting warming to 1.5 degrees Celsius. For more about the IPCC methodology and how it differs from other carbon-budget estimates (for example, a 420 GtCO<sub>2</sub> for a 66 percent chance, and 580 GtCO<sub>2</sub> for a 50 percent chance), see Myles R. Allen et al., *Special report: Global warming of 1.5°C*, IPCC, 2018, [ipcc.ch](https://www.ipcc.ch).

<sup>4</sup>Karsten Haustein et al., “A real-time global warming index,” *Nature*, November 13, 2017, [Nature Scientific Reports 7, Article Number 15417, nature.org](https://doi.org/10.1038/nature24146); Richard J. Millar and Pierre Friedlingstein, “The utility of the historical record for assessing the transient climate response to cumulative emissions,” *Philosophical Transactions of the Royal Society*, May 2018, Volume 376, Number 2119, [royalsocietypublishing.org](https://royalsocietypublishing.org).

<sup>5</sup>Any discussion of methane in this article, unless noted otherwise, assumes GWP20 with inclusion of climate–carbon feedbacks; GWP20 = 20-year global warming potential (GWP). See Gunnar Myhre et al., “Anthropogenic and natural radiative forcing,” *AR5 Climate change 2013: The physical science basis*, Intergovernmental Panel on Climate Change, 2018, Assessment Report 5, Chapter 8, [ipcc.ch](https://www.ipcc.ch).

<sup>6</sup>Assumes a 50 percent reduction in gross anthropogenic CO<sub>2</sub> emissions—approximately 19 gigatons (Gt)—coupled with approximately 2 Gt of negative emissions, for a net reduction of 54 percent (reaching net emissions of approximately 17 Gt); 2010 emissions at 38.5 Gt, see Joeri Rogelj et al., “Mitigation pathways compatible with 1.5°C in the context of sustainable development,” *Special report: Global warming of 1.5°C*, Intergovernmental Panel on Climate Change, 2018, Chapter 2, [ipcc.ch](https://www.ipcc.ch).

# Delivering the emissions reduction needed to reach a 1.5-degree pathway would imply a large dietary shift: reducing the share of ruminant animal protein in the global protein-consumption mix by half.

greenhouse gases methane and nitrous oxide—meaning that this critical system contributes 20 percent of global GHG emissions<sup>7</sup> each year. Moreover, population growth, rising per capita food consumption in emerging markets, and the sustained share of meat in diets everywhere mean that agricultural emissions are poised to increase by about 15 to 20 percent by 2050, absent changes in global diets and food-production practices.

The livestock dilemma. The biggest source of agricultural emissions—almost 70 percent—is from the production of ruminant meat. Animal protein from beef and lamb is the most GHG-intensive food, with production-related emissions more than ten times those of poultry or fish and 30 times those of legumes. The culprit? Enteric fermentation inherent in the digestion of animals such as cows and sheep. In fact, if the world's cows were classified as a country in the emissions data, the impact of their GHG emissions (in the form of methane) would put cows ahead of every country except China.

Delivering the emissions reduction needed to reach a 1.5-degree pathway would imply a large dietary shift: reducing the share of ruminant animal protein in the global protein-consumption mix by half, from about 9 percent in current projections for 2050 to about 4 percent by 2050.

Changing the system. The agricultural system itself would need to change, too. Even if consumption of

animal protein dropped dramatically, in a 1.5-degree world, the emissions from remaining agricultural production would need to fall as well.

New cultivation methods would help. Consider rice, which currently accounts for 14 percent of total agricultural emissions. The intermittent flooding of rice paddies is a common, traditional growing method—the flooding prevents weeds—that results in outsize methane emissions as organic matter rots. To reach a 1.5-degree pathway, new cultivation approaches would need to prevail, leading to a 53 percent reduction in the intensity of methane emissions from rice cultivation by 2050.

Finally, about one-third of global food output is currently lost in production or wasted in consumption. To achieve a 1.5-degree pathway, that proportion could not exceed 20 percent by 2050. Curbing waste would reduce both the emissions associated with growing, transporting, and refrigerating food that is ultimately wasted, and the methane released as the organic material in wasted food decomposes.

## Halting deforestation

Deforestation—quite often linked to agricultural practices, but not exclusively so—is one of the largest carbon-dioxide emitters, accounting for nearly 15 percent of global CO<sub>2</sub> emissions.

Deforestation's outsize impact stems from the fact that removing a tree both adds emissions to the

<sup>7</sup> Does not include land use, land-use change, or forestry. Non-CO<sub>2</sub> emissions converted using 20-year global-warming-potential values. See T. F. Stocker et al., *AR5 Climate change 2013: The physical science basis*, Intergovernmental Panel on Climate Change, 2018, Assessment Report 5, ipcc.ch.

atmosphere (most deforestation today involves clearing and burning) and removes that tree's potential as a carbon sink.

Even after accounting for ongoing reforestation efforts, deforestation today claims an area close to the size of Greece every year. Achieving a 1.5-degree pathway would mean dramatically slowing this. By 2030, if all fossil-fuel emissions were rapidly reduced (as in our first scenario), and all sectors of the economy pursued rapid decarbonization, deforestation would still need to fall about 75 percent. In the other two scenarios, where reduced deforestation serves to help counteract slower decarbonization elsewhere, deforestation would need to be nearly halted as early as 2030. Either outcome would require a combination of actions (including regulation, enforcement, and incentives such as opportunity-cost payments to farmers) outside the scope of our analysis.

## Shift 2: Electrifying our lives

Electrification is a massive decarbonization driver for transportation and buildings—powerful both in its own right and in combination with complementary changes such as increased public-transportation use and the construction or retrofitting of more efficient buildings.

### Electrified road transport

The road-transportation sector—passenger cars and trucks, buses, and two- and three-wheeled vehicles—accounts for 15 percent of the carbon dioxide emitted each year. Nearly all of the fuels used in the sector today are oil based. To decarbonize, this sector would need to shift rapidly to a cleaner source of energy, which in the scenarios we modeled was predominantly electricity, and leverage either batteries with sustainably produced electricity or fuel cells with sustainably produced hydrogen to power an electric engine.<sup>8</sup> (Biofuels would also contribute to road transportation. The role of those fuels is discussed later.)

In our first scenario (rapid fossil-fuel reduction), road transportation could reach a 1.5-degree pathway through a rapid migration to EVs powered by a mix of batteries and hydrogen fuel cells, and supported by deep, renewable power penetration. Sales of internal-combustion vehicles would account for less than half of global sales by 2030 and be fully phased out by 2050.

These shifts would, in turn, prompt a rapid increase in demand for batteries, challenging that industry to scale more quickly and improve its sustainability (for more, see “Building a more sustainable battery industry,” on McKinsey.com).

One lever for smoothing the transition would be reducing overall mileage driven by personal vehicles through policies that discouraged private-vehicle usage, such as banning cars in city centers, taxing vehicles on a per-mile-traveled basis, and encouraging the use of public transport. By 2030, such measures could reduce by about 10 percent the number of miles traveled by passenger cars.

To be sure, the rate of change implied in this scenario is dramatic (sales of EV passenger vehicles,<sup>9</sup> for example, would need to grow nearly 25 percent a year between 2016 and 2030). Nonetheless, the scope of the task will be familiar to global OEMs, which have themselves been prioritizing the shift to electrification.

What if the electrification of road transportation was still aggressive but more gradual—specifically, if sales of internal-combustion vehicles still accounted for more than half of total sales by 2030, as we assumed in our second scenario? In that case, reaching a 1.5-degree pathway would necessitate dramatic levels of CO<sub>2</sub> sequestration, implying the need for unprecedented levels of reforestation to cover the difference, as we describe later.

### Electrified buildings

Electrification would also help decarbonize buildings, where CO<sub>2</sub> emissions represent about

<sup>8</sup>In our scenarios, electrification also plays a modest role in decarbonizing marine transport, especially for coastal vessels such as ferries. In aviation, electrification could account for up to 2 percent of the sector's final energy consumption by 2030 and about 6 percent by 2050.

<sup>9</sup>Includes battery electric, fuel-cell electric, plug-in, and hybrid vehicles.

7 percent of the global total. Space and water heating, which typically rely on fossil fuels such as natural gas, fuel oil, and coal, are the primary emission contributors. By 2050, electrifying these two processes in those residences and commercial buildings where it is feasible would abate their 2016 heating emissions by 20 percent (if the electricity were to come from clean sources). By expanding the use of district heating and blending hydrogen or biogas into gas grids for cooking and heating, the buildings sector could potentially reduce nearly an additional 40 percent of emissions. Both would be required to reach a 1.5-degree pathway in our rapid fossil-fuel-reduction scenario.

Across all three scenarios, the share of households with electric space heating would have to increase from less than 10 percent today to 26 percent by 2050. To make the most of electric heating, buildings would need to replace traditional heating equipment with newer, more efficient technologies. Improved insulation and home energy management would also be necessary to maximize the benefits of electric heating and enable further emissions reductions by 2050.

The good news is that electric technologies are already available at scale, and their economics are often positive. However, the combination of higher up-front costs, long payback times, and market inefficiencies often prevents consumers and companies from acting.<sup>10</sup> Moreover, the average life span of currently installed (but less efficient) equipment can span decades, making inertia tempting for many asset owners, and a broad-based shift to electric heating more challenging.

### Shift 3: Adapting industrial operations

The role of electrification could not stop with buildings and cars. It would need to extend across a broad swath of industries as part of a collection of operational adaptations that would be part of achieving a 1.5-degree pathway.

#### Electrified industries

Industrial subsectors with low- and medium-temperature heat requirements, such as construction, food, textiles, and manufacturing, would need to accelerate electrification of their operations relatively quickly. By 2030, more than 90 percent of the abatement for mid- to low-temperature industries depends on electrifying production with power sourced from clean-energy sources. All told, these industries would need to electrify at more than twice their current level by 2050 (from 28 percent in 2016 to 76 percent in 2050) to achieve a 1.5-degree pathway (for more about the economics of industry electrification, see “Hybrid equipment: A first step to industry electrification,” on McKinsey.com).

Electrification would prove more difficult for process industries with high-temperature requirements, such as iron and steel, or cement (among the biggest CO<sub>2</sub> emitters). These subsectors, along with others such as chemicals, mining, and oil and gas that are also challenging and expensive to decarbonize, would put a premium on efficiency efforts (including recycling and the use of alternative materials) and would depend heavily on innovation in hydrogen and clean fuels.

#### Greater industrial efficiency

Across the board, embracing the circular economy and boosting efficiency would enable a wide cross-section of industries to decrease GHG emissions, reduce costs, and improve performance (see sidebar “Carbon avoided is carbon abated”). By 2050, for example, nearly 60 percent of plastics consumption could be covered by recycled materials.<sup>11</sup> Similarly, steelmakers might be able to reduce GHG emissions by further leveraging scrap steel, which today accounts for nearly one-third of production. Cement manufacturers, meanwhile, would need to abate their current CO<sub>2</sub> emissions, which accounted for 6 percent of global CO<sub>2</sub> emissions in 2016, by more than 7 percent by 2030 through a range of short-term efficiency improvements, including the greater use of advanced analytics.

<sup>10</sup>For more on improving energy efficiency in buildings, see “Resource revolution: Meeting the world’s energy, materials, food, and water needs,” McKinsey Global Institute, November 2011, on McKinsey.com, and view the interactive.

<sup>11</sup>Thomas Hundertmark, Mirjam Mayer, Chris McNally, Theo Jan Simons, and Christof Witte, “How plastics waste recycling could transform the chemical industry,” December 2018, McKinsey.com.



## Carbon avoided is carbon abated

The role of greater efficiency in achieving a 1.5-degree pathway goes beyond improving the operations of any single industry. After all, carbon avoided is as beneficial as carbon abated. As part of our

analysis, we therefore studied the impact of greater efficiency, as well as how smart substitution of lower-carbon alternatives and demand-reducing regulations could help lower CO<sub>2</sub> across all scenarios. Taken

together, these actions could potentially, by 2050, help bypass about 15 percent of today's emissions (exhibit).

Exhibit

### By 2050, reducing demand could help bypass approximately 15 percent of today's CO<sub>2</sub> emissions.

#### Efficiencies

Insulation and home-energy management could reduce demand for space heating and cooling, lowering CO<sub>2</sub> emissions 30% by 2050

#### Recycling

Replacing an additional 20% of inputs to the steel-production process with scrap steel could lower emissions from iron ore use

#### Consumption patterns shift

Remote communication and modal shifts in transportation could reduce emissions in the aviation sector 10% by 2030

#### Substitutes

Alternative building materials—eg, cross-laminated timber—could reduce the demand for cement<sup>1</sup>

Recycling could cover ~60% of plastics demand by 2050

Measures such as a tax on internal-combustion-engine vehicles—eg, London's congestion charge—would decrease the kilometers traveled per vehicle

<sup>1</sup>In our scenarios, electrification also plays a modest role in decarbonizing marine transport, especially for coastal vessels such as ferries. In aviation, electrification could account for up to 2 percent of the sector's final energy consumption by 2030 and about 6 percent by 2050.

Source: McKinsey Global Energy Perspective 2019: Reference Case; McKinsey 1.5°C scenario analysis

#### Tackling fugitive methane

Another big operational adaptation would be “fugitive methane,” or the natural gas that is released through the activities of oil and gas companies, as well as from coal-mining companies (Exhibit 3). Each would need to tackle the issue to reach a 1.5-degree pathway.

For oil and gas companies, methane is the largest single contributor of GHGs. The good news, as our colleagues write, is that, while eliminating fugitive methane is challenging, many abatement options are available—often with favorable economics (for more, see “Meeting big oil's decarbonization challenge,” on McKinsey.com).

Coal mines, meanwhile, release the gas as part of their underground operations. Solutions for capturing methane (and using it to generate power) exist but are not commonly implemented.<sup>12</sup> Moreover,

there are no ready solutions for all types of mines, and the investment is not economical in many cases.

#### Shift 4: Decarbonizing power and fuel

Widespread electrification would hold enormous implications for the power sector. We estimate that electrification would at least triple demand for power by 2050, versus a doubling of demand, as reported in Global Energy Perspective 2019: Reference Case.<sup>13</sup> The power system would have to decarbonize in order for the downstream users of that electricity—everything from factories to fleets of electric vehicles—to live up to their own decarbonization potential. Renewable electricity generation is therefore a pivotal piece of the 1.5-degree puzzle. But it's not the only piece: expanding the hydrogen market would be vital, given the molecule's versatility as an energy

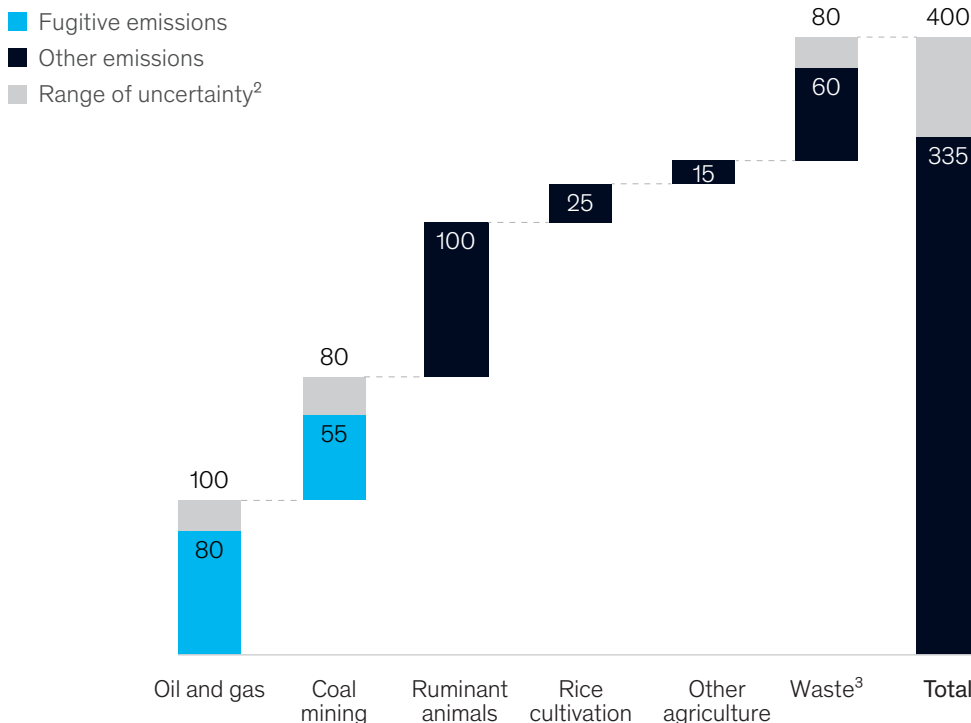
<sup>12</sup>In the United States, for example, the Coalbed Methane Outreach Program—part of the Environmental Protection Agency—works with the coal-mining industry to support project development and to help overcome technical and other barriers to implementation.

<sup>13</sup>The impact of increased demand for electricity on its price is beyond the scope of our analysis. For further discussion of the issue, see *Global Energy Perspective 2019: Reference Case*, January 2019, McKinsey.com; and Arnout de Pee, Dickon Pinner, Occo Roelofsen, Ken Somers, Eveline Speelman, and Maaike Witteveen, “How industry can move toward a low-carbon future,” July 2018, McKinsey.com, which examines the trade-offs involved in the decarbonization of four industrial commodities: ammonia, cement, ethylene, and steel.

### Exhibit 3

## Methane emissions would need to be reduced to reach a 1.5°C pathway.

Anthropogenic methane emissions,<sup>1</sup> 2016, metric megatons of methane (MtCH<sub>4</sub>)



Note: Major uncertainties affect estimates of fugitive emissions. There is no global consensus on their monitoring.

<sup>1</sup> The methane emissions depicted here—when expressed as metric gigatons of CO<sub>2</sub> equivalents and based on 20-year global-warming-potential values (GWP20) from IPCC Assessment Report 5—are as follows: oil and gas (7 Gt); coal mining (5 Gt); ruminant animals (8 Gt); rice cultivation (2 Gt); other agriculture (1 Gt); waste (6 Gt). GWP20 values include climate-carbon feedbacks.

<sup>2</sup> Ranges of uncertainty: for oil and gas, assumes upper bound of +25% (shown); for coal mining, assumes a lower bound of -45%, an average of 55 Mt (shown), and an upper bound of +40% (shown); for waste, assumes a range based on lowest and highest values in available literature (shown).

<sup>3</sup> Includes treatment and disposal of solid waste, incineration and open burning of waste, and wastewater treatment and discharge.

Source: Emissions Database for Global Atmospheric Research (EDGAR), 2015; FAOSTAT; Global Carbon Project; IEA; McKinsey *Global Energy Perspective 2019: Reference Case*; McKinsey 1.5°C scenario analysis

source. Expanding the use of bioenergy would be important, too.

### Renewables

Replacing thermal assets with renewable energy would require a dramatic ramp-up in manufacturing capacity of wind turbines and solar panels. By 2030, yearly build-outs of solar and wind capacity would

need to be eight and five times larger, respectively, than today's levels.<sup>14</sup>

It would also entail a massive reduction in coal- and gas-fired power generation. Indeed, to remain on a 1.5-degree pathway, coal-powered electricity generation would need to decrease by nearly 80 percent by 2030 in our rapid fossil-fuel-reduction

<sup>14</sup> Nuclear power could also contribute to the supply of low-carbon power, but it is largely outside the scope of our analysis. In our modeling, we assumed that nuclear capacity will grow 6 percent between 2020 and 2050, in line with McKinsey's *Global Energy Perspective 2020: Reference Case* (forthcoming on McKinsey.com).

(continued on page 27)

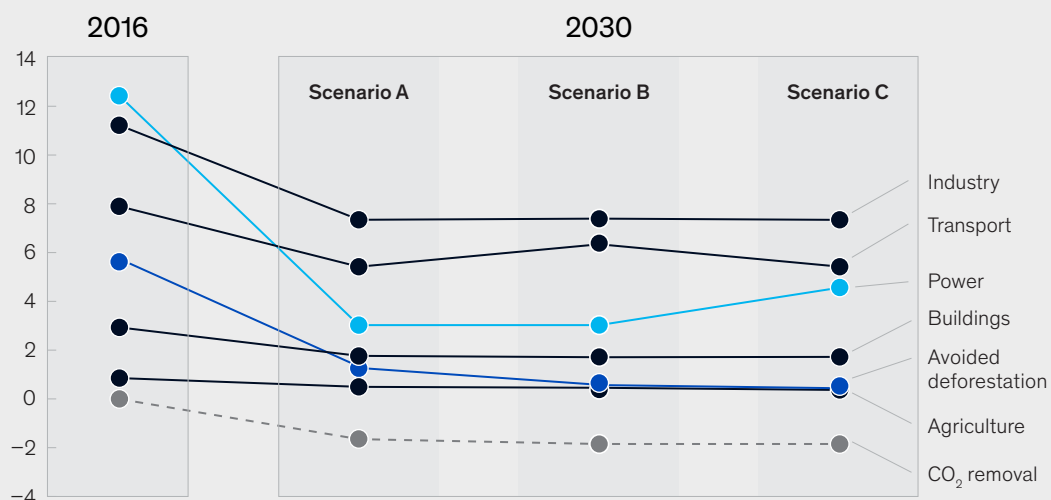
# Three paths to 1.5°C

To help understand the challenges of mitigating climate change, we modeled three scenarios. This allowed us to account for flexibility in how fast various large emitters of greenhouse gases (GHGs) might decarbonize—without being predictive. While the scenarios are not forecasts, we hope they nonetheless serve as a useful addition to existing analytic perspectives on GHG abatement. The scenarios address

only CO<sub>2</sub> emissions (the most prevalent anthropogenic greenhouse gas and key to any GHG-abatement scenario). While achieving a 1.5°C pathway is technically achievable, it would require all sectors to decarbonize. Should one lag behind, others would need to move faster. The scenarios help define some of these trade-offs.

## Three challenging—yet possible—scenarios could limit warming.

Emissions per source, metric gigatons of CO<sub>2</sub> (GtCO<sub>2</sub>) in 2016 and 2030



### Scenario A

The decarbonization pace is set by technology readiness, cost-effectiveness, and ease of implementation

### Scenario B

Oil fuels transport for longer; reforestation and curbing deforestation abate the additional emissions

### Scenario C

Coal and gas generate power for longer; reforestation and curbing deforestation abate the surplus CO<sub>2</sub>

Source: McKinsey Global Energy Perspective 2019: Reference Case; McKinsey 1.5°C scenario analysis

## Scenario A: Significant and steady decarbonization

A paced transition, enabled by regulation and targeted investment, would require immediate action but would support a significant and

steady decrease in emissions. By 2030, all sectors/sources would have abated at least 30% of their 2016 CO<sub>2</sub> emissions.

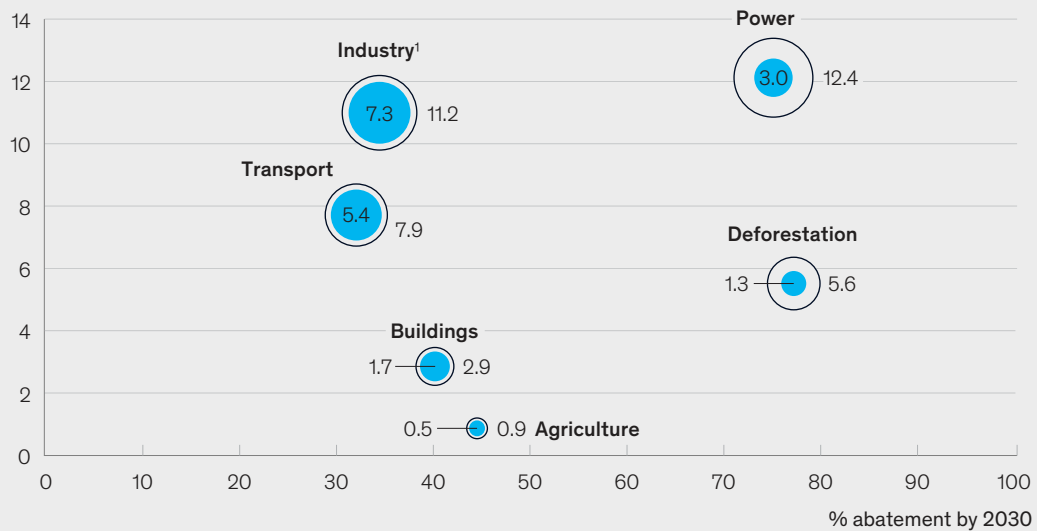
Year of emissions



Volume of emissions, metric gigatons of CO<sub>2</sub> (GtCO<sub>2</sub>)

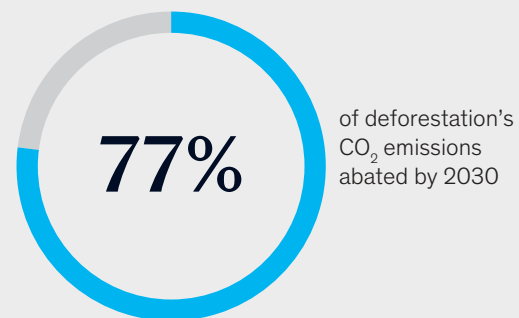
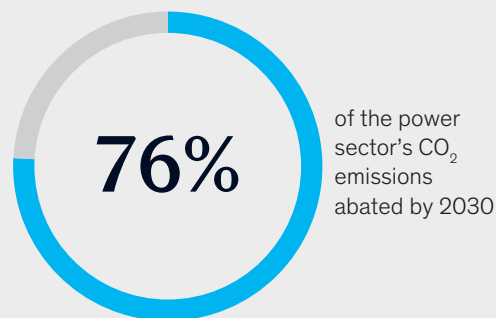


CO<sub>2</sub> emissions per source in 2016,<sup>2</sup> GtCO<sub>2</sub>



### The heavy hitters

Share of category's total 2016 emissions



<sup>1</sup>Includes cement, chemical production, iron and steel, mining, oil and gas, and low- to medium-temperature and high-temperature industries, among others.

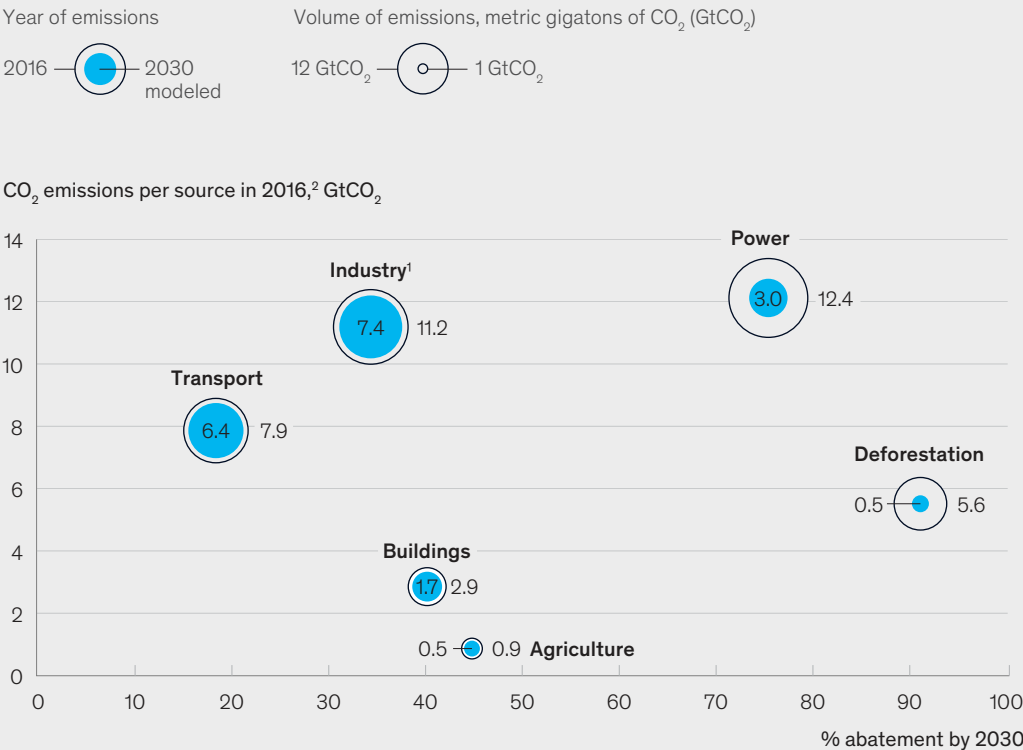
<sup>2</sup>Carbon-dioxide removal (not pictured here) would abate 4% of 2016 CO<sub>2</sub> emissions in Scenario A.

Source: McKinsey 1.5°C scenario analysis

## Scenario B: Oil decarbonizes more slowly

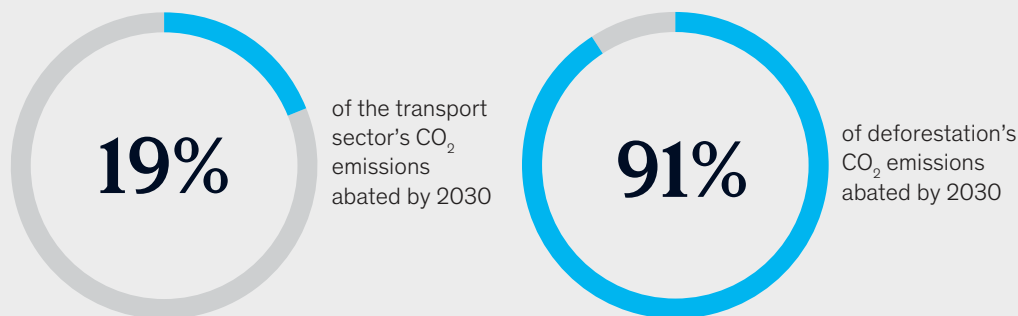
Oil continues to be the major fuel for transport, and that sector decarbonizes more slowly. To compensate, reforestation would need to speed up, and 90% of CO<sub>2</sub> emissions from

deforestation would have to be abated by 2030. In this scenario, all sectors/sources except transport would manage to abate by at least one-third of their 2016 emissions by 2030.



### Trade-offs

Share of category's total 2016 emissions



<sup>1</sup> Includes cement, chemical production, iron and steel, mining, oil and gas, and low- to medium-temperature and high-temperature industries, among others.

<sup>2</sup> Carbon-dioxide removal (not pictured here) would abate 5% of 2016 CO<sub>2</sub> emissions in Scenario B.

Source: McKinsey 1.5°C scenario analysis

## Scenario C: Power decarbonizes more slowly

Coal and gas generate power for longer, compensated by faster reforestation, and abate 90% of all CO<sub>2</sub> emissions

from deforestation. In this scenario, all sectors/sources would abate more than 30% of their emissions.

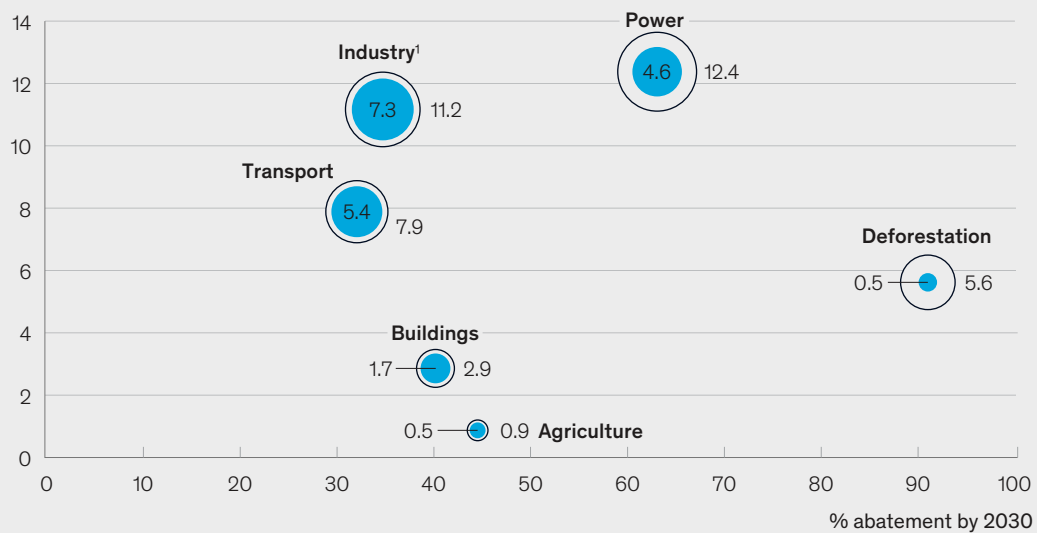
Year of emissions



Volume of emissions, metric gigatons of CO<sub>2</sub> (GtCO<sub>2</sub>)

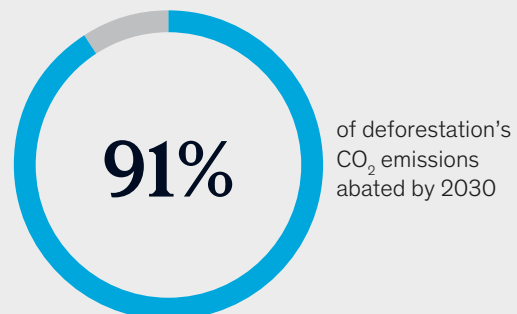
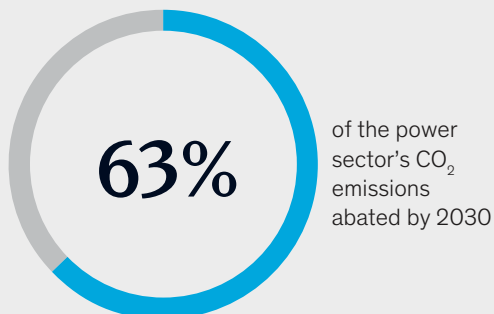


CO<sub>2</sub> emissions per source in 2016,<sup>2</sup> GtCO<sub>2</sub>



### Trade-offs

Share of category's total 2016 emissions



<sup>1</sup>Includes cement, chemical production, iron and steel, mining, oil and gas, and low- to medium-temperature and high-temperature industries, among others.

<sup>2</sup>Carbon-dioxide removal (not pictured here) would abate 4% of 2016 CO<sub>2</sub> emissions in Scenario C.

Source: McKinsey 1.5°C scenario analysis



scenario. Even in the scenario where coal and gas generate power for longer, the reduction would need to be about two-thirds by 2030. The sheer scope of this shift cannot be overstated. Coal today accounts for about 40 percent of global power generation. What's more, by 2030 the amount of electricity generated by natural gas would have to decrease by somewhere between 20 and 35 percent. As it stands, nearly one-quarter of the world's power is generated using natural gas.

A fast migration to renewable energy would bring unique regional challenges, most notably the need to match supply and demand at times when the sun doesn't shine and the wind doesn't blow. In the nearer term, a mix of existing approaches could help with day-to-day and seasonal load balancing, although emerging technologies such as hydrogen, carbon capture and storage, and more efficient long-distance transmission would ultimately be needed to reach a 1.5-degree pathway.

#### **Bioenergy**

Increasing the use of sustainably sourced bioenergy—for instance, biokerosene, biogas, and biodiesel—would also be required in any 1.5-degree-pathway scenario. Our scenarios approached bioenergy conservatively (abating about 2 percent of the CO<sub>2</sub> needed by 2030 to reach a 1.5-degree pathway). Its most pressing mandate over that time frame would be substituting for oil-based fuels in aviation and marine transport, until which time sustainably sourced synthetic fuels

would account for a larger share. Nonetheless, any scale-up of bioenergy would need to acknowledge the realities of land use, and it would also need to strike a balance between the desire for sustainable energy, on the one hand, and the basic human need to feed a growing world population, on the other.

#### **Hydrogen**

Hydrogen produced from renewable energy—so-called green hydrogen—would play a huge part in any 1.5-degree pathway. “Blue hydrogen,” which is created using natural gas and the resulting CO<sub>2</sub> emissions stored via carbon capture and storage, would also play a role. This is because about 30 percent of the energy-related CO<sub>2</sub> emitted across sectors is hard to abate with electricity only—for example, because of the high heat requirements of industries such as steelmaking. Hydrogen's potential is strongest in the steelmaking and chemical industries; the aviation, maritime, and short-haul trucking segments of the transport sector; oil- and gas-heated buildings; and peak power generation. In addition, green hydrogen has at least some potential in a range of other sectors, including cement, manufacturing, passenger cars, buses and short-haul trucks, and residential buildings. Scaling the hydrogen market would require efforts across the board, from building the supporting infrastructure to store and distribute it to establishing new technical codes and safety standards. For more, see the Hydrogen Council's 2017 report, *Hydrogen scaling up: A sustainable pathway for the global energy transition*.

**Even in the scenario where coal and gas generate power for longer, the reduction would need to be about two-thirds by 2030.**

### **Shift 5: Ramping up carbon-capture and carbon-sequestration activity**

Deep decarbonization would also require major initiatives to either capture carbon from the point at which it is generated (such as ammonia-production facilities or thermal-power plants) or remove carbon dioxide from the atmosphere itself. Currently, it is impossible to chart a 1.5-degree pathway that does not remove CO<sub>2</sub> to offset ongoing emissions. The math simply does not work.

#### **Carbon capture, use, and storage**

Developing the nascent carbon capture, use, and storage (CCUS) industry would be critical to remaining on a 1.5-degree pathway. In simplest terms, this suite of technologies collects CO<sub>2</sub> at the source (say, from industrial sites). CCUS would prevent emissions from entering the atmosphere by compressing, transporting, and either storing the carbon dioxide underground or using it as an input for products.

In the first, more rapid decarbonization scenario, the amount of CO<sub>2</sub> captured via CCUS each year would have to multiply by more than 125 times by 2050 from 2016 levels, to ensure that emissions stay within the 1.5-degree-pathway budget. This is a tall order that exceeds the relatively bullish forecasts of McKinsey researchers who have been investigating both the challenges and the potential of CCUS, suggesting that more innovation and regulatory support would be needed for it to play a central role.

#### **Technology-based carbon-dioxide removal**

While reducing CO<sub>2</sub> emissions is a vital part of reaching a 1.5-degree pathway, it would not be enough by itself. Additional carbon dioxide would need to be removed from the atmosphere. Carbon-dioxide removal involves capturing and permanently sequestering CO<sub>2</sub> that has already been emitted, through either nature-based solutions or approaches that rely on technology, which are promising but nascent. Examples of the latter include direct air capture (which is operating at a pilot plant in Iceland).

#### **Reforestation at scale**

Even in an extremely optimistic scenario for these technologies, though, we would still need large-scale, nature-based carbon-dioxide removal, which is proved at scale: it is what trees and plants have been doing for millions of years. Over the next decade, a massive, global mobilization to reforest the earth would be required to achieve a 1.5-degree pathway. In our scenarios, reforestation represents the key lever to compensate for the hardest-to-abate sectors, particularly for pre-2030 emissions.

All the scenarios we modeled would require rapid reforestation between now and 2030. At the height of the effort in that year, an area the size of Iceland would need to be reforested annually. By 2050, on top of nearly avoiding deforestation and replacing any forested areas lost to fire, the world would need

**Over the next decade, a massive, global mobilization to reforest the earth would be required to achieve a 1.5-degree pathway.**

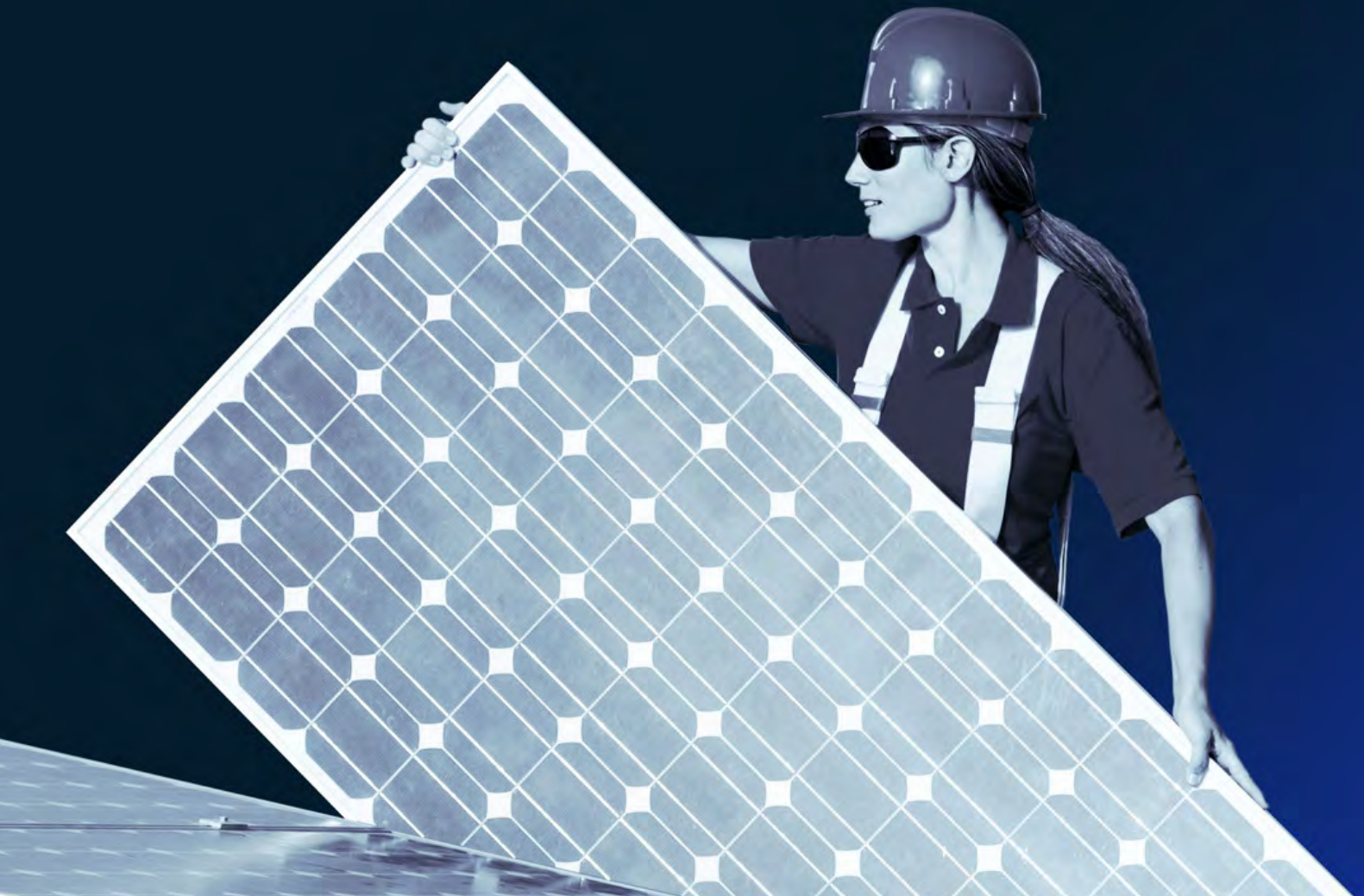
to have reforested more than 300 million hectares (741 million acres)—an area nearly one-third the size of the contiguous United States. As we noted earlier, the pace of reforestation would need to be faster still should either the transport or power-generation sectors decarbonize more slowly than depicted in our scenarios. Under those circumstances, the requisite annual reforestation would need to be nearly half the size of Italy by 2030.

How feasible would this be? The necessary land appears to be available. Mass reforestation has taken place, admittedly at a much smaller scale, in China. And carbon-offset markets could help catalyze reforestation (and innovation). That said, it is difficult to imagine reforestation taking place on the scale or at the pace described in this article absent coordinated government action—on top of the shifts described in the scenarios themselves.

Will these five shifts become the building blocks of an orderly transition to a decarbonized global economy? Or will slow progress against them be a warning sign that the climate is headed for rapid change in the years ahead? While unknowable today, the answers to these questions are likely to emerge in a remarkably short period of time. And if the global economy is to move to a 1.5-degree pathway, business leaders of all stripes need knowledge of the shifts, clarity about each one's relevance to their companies, insights into the difficult trade-offs that will be involved, and creativity to forge solutions that are as urgent and far-reaching as the climate challenge itself.

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# How a post-pandemic stimulus can both create jobs and help the climate

The \$10 trillion in stimulus measures that policy makers have allocated could be decisive for the world's low-carbon transition. Here's how organizations can bring economic and environmental priorities together.

*This article was a collaborative, global effort by Hauke Engel, Alastair Hamilton, Solveigh Hieronimus, and Tomas Naclér, with David Fine, Dickon Pinner, Matt Rogers, Sophie Bertreau, Peter Cooper, and Sebastien Leger, representing views from the Public & Social Sector and Sustainability Practices.*

**The tragedy of the COVID-19 crisis** has taken much attention away from the threat of climate change, as institutions devoted themselves to protecting lives and livelihoods. Sustaining an effective public-health response remains a top concern for many policy makers and business executives. Severe job losses and revenue declines in some sectors, along with the high likelihood of an economic recession, have also compelled policy makers to mount an unprecedented financial response, which already exceeds \$10 trillion, according to McKinsey estimates.

Important as it is to repair the economic damage, a swift return to business as usual could be environmentally harmful, as the world saw after the 2007–08 financial crisis. The ensuing economic slowdown sharply reduced global greenhouse-gas emissions in 2009. But by 2010, emissions had reached a record high, in part because governments implemented measures to stimulate economies, with limited regard for the environmental consequences. The danger now is that the same pattern will repeat itself—and today the stakes are even higher. The period after the COVID-19 crisis could determine whether the world meets or misses the emissions goals of the 2015 Paris Agreement, which were set to limit global warming to 1.5°C to 2°C.

Achieving those goals is a distinct possibility. A low-carbon recovery could not only initiate the significant emissions reductions needed to halt climate change but also create more jobs and economic growth than a high-carbon recovery would. Our analysis of stimulus options for a European country suggests that mobilizing €75 billion to €150 billion of capital could yield €180 billion to €350 billion of gross value added, generate up to three million new jobs, and enable a carbon-emissions reduction of 15 to 30 percent by 2030. Such a package need not involve economic compromises. A recent survey of top economists shows that stimulus measures targeting

good environmental outcomes can produce as much growth and create as many jobs as environmentally neutral or detrimental measures.<sup>1</sup> But a high-carbon recovery could make it hard to meet the goals of the Paris Agreement, and heavy relief and stimulus spending might leave governments too debt-strapped to pay later for emissions cuts.

Finding a low-carbon, high-growth recovery formula isn't easy. It requires assessing stimulus measures with respect to complex factors, including socioeconomic impact, climate impact, and feasibility. But our analysis highlights the chance for policy makers to assemble a package that quickly creates jobs and economic demand, produces steady growth, and accelerates the uptake of zero-carbon technologies. Governments can use the framework described in this article to design and carry out a low-carbon recovery agenda that could meet the immediate economic needs and improve the long-term well-being of their people.

## **The recovery from the COVID-19 economic crisis coincides with a pivotal time in the fight against climate change**

The coronavirus pandemic has not only had tragic effects on health and lives but also taken an immense toll on livelihoods. That cost is visible in the rising unemployment figures that many countries continue to report. And the worst may be yet to come. A McKinsey analysis published in April suggests that lockdowns could make up to 60 million jobs in Europe and up to 57 million jobs in the United States vulnerable: subject to reductions in hours or pay, temporary furloughs, or permanent discharge.<sup>2</sup> In one McKinsey scenario for a muted world recovery, the EU-27 unemployment rate peaks at 11.2 percent in 2021 and remains unlikely to achieve 2019 levels even by 2024.<sup>3</sup>

<sup>1</sup> Cameron Hepburn et al, "Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change?," *Oxford Review of Economic Policy* working paper, number 20-02, 36(S1), May 4, 2020.

<sup>2</sup> David Chinn, Julia Klier, Sebastian Stern, and Sahil Tesfu, "Safeguarding Europe's livelihoods: Mitigating the employment impact of COVID-19," April 19, 2020, McKinsey.com; Susan Lund, Kweilin Ellingrud, Bryan Hancock, and James Manyika, "COVID-19 and jobs: Monitoring the US impact on people and places," McKinsey Global Institute, April 29, 2020, McKinsey.com; David Fine, Julia Klier, Deepa Mahajan, Nico Raabe, Jörg Schubert, Navjot Singh, and Seckin Ungur, "How to rebuild and reimagine jobs amid the coronavirus crisis," April 15, 2020, McKinsey.com.

<sup>3</sup> David Chinn, Julia Klier, Sebastian Stern, and Sahil Tesfu, "Safeguarding Europe's livelihoods: Mitigating the employment impact of COVID-19," April 19, 2020, McKinsey.com.



# Targeted low-carbon programs could restart growth and hiring while ushering in a more environmentally sustainable “next normal.”

Although the COVID-19 crisis has brought sickness and economic hardship to countless households, the urgency of responding to the pandemic is arguably matched by the urgency of addressing climate change.<sup>4</sup> Already, climate change brings on storms, floods, wildfires, and other natural disasters that inflict billions of dollars in damage. Additional warming over the next decade is locked in, so it is crucial to plan for physical climate risk.<sup>5</sup> To avert the further buildup of physical risk and to keep temperatures below thresholds that would trigger runaway warming, significant near-term reductions of greenhouse-gas emissions must happen. Achieving them will require rapid, capital-intensive action across every part of the economy.<sup>6</sup>

The simultaneity of the COVID-19 crisis and the climate challenge means that the post-pandemic recovery will be a decisive period for fending off climate change. In the aftermath of COVID-19, any number of factors could slow climate action: reduced political attention (this year’s UN climate summit, COP26, has been postponed to 2021), the easing or delay of environmental regulations in the interest of economic growth, depressed oil prices that make low-carbon technologies less competitive, or stimulus programs that consume funds governments might otherwise invest in a zero-carbon transition.

By contrast, a climate-smart approach to economic recovery could do much to put the world on an emissions pathway that would hold the average

temperature increase to a relatively safe 1.5°C. Since recovery efforts usually involve much higher public spending than governments lay out in noncrisis years, they can bring about extensive, lasting changes in the structure of national and regional economies. As we explain in the next section, targeted low-carbon programs could restart growth and hiring while ushering in a more environmentally sustainable “next normal.”

## Low-carbon stimulus spending can spur economic recovery and job creation

In many countries, efforts to provide economic relief and restart growth after the pandemic are well under way. Governments around the world have devoted more than \$10 trillion to economic-stimulus measures. McKinsey estimates that the G-20 nations have announced fiscal measures averaging 11 percent of GDP—three times the response to the 2008–09 financial crisis. Some countries have said they will commit up to 40 percent of GDP to their economic-stimulus packages. Preliminary reports on the European Commission’s green-recovery plan indicate that it will provide some €1 trillion in economic assistance.

Support is mounting for a low-carbon recovery from the COVID-19 economic crisis. The informal green-recovery alliance, launched in April by 12 environment ministers from European countries, 79 members of the European Parliament, and 37

<sup>4</sup>Dickon Pinner, Matt Rogers, and Hamid Samandari, “Addressing climate change in a post-pandemic world,” *McKinsey Quarterly*, April 7, 2020, McKinsey.com.

<sup>5</sup>Jonathan Woetzel, Dickon Pinner, Hamid Samandari, Hauke Engel, Mekala Krishnan, Brodie Boland, and Carter Powis, “Climate risk and response: Physical hazards and socioeconomic impact,” McKinsey Global Institute, January 16, 2020, McKinsey.com.

<sup>6</sup>Kimberly Henderson, Dickon Pinner, Matt Rogers, Bram Smeets, Christer Tryggstad, and Daniela Vargas, “Climate math: What a 1.5-degree pathway would take,” *McKinsey Quarterly*, April 30, 2020, McKinsey.com.



CEOs and business associations, has been joined by more than 50 banking and insurance CEOs. Top executives at upward of 150 companies signed a public statement calling for a net-zero recovery. European Commission president Ursula von der Leyen and German chancellor Angela Merkel have said that the European Green Deal should form the center of Europe's economy recovery plan. Populations around the world favor recovery policies that also address climate change (Exhibit 1).

effectively as—or better than—environmentally neutral or harmful programs. In a survey reported in a recent working paper, more than 200 economists and economic officials said that “green” economic-recovery measures performed at least as well as others did.<sup>7</sup> An econometric study of government spending on energy technologies showed that spending on renewables creates five more jobs per million dollars invested than spending on fossil fuels (Exhibit 2).<sup>8</sup>

Amid debate over how to spend stimulus funds, some have questioned whether low-carbon programs generate sufficiently strong economic returns. Yet research suggests that many such programs stimulate growth and create jobs as

Faced with the COVID-19 recession, governments don't have to compromise economic priorities for the sake of environmental ones. By carefully designing low-carbon stimulus packages, they can address both sets of priorities at once.

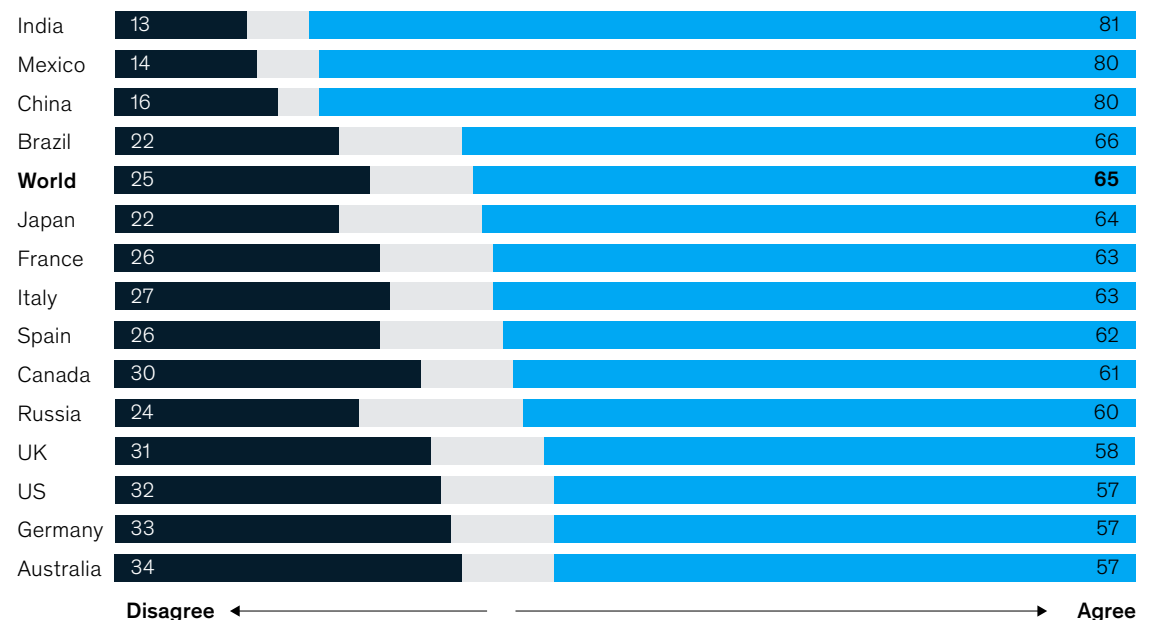
<sup>7</sup>“Will COVID-19 fiscal recovery packages accelerate or retard progress on climate change?”

<sup>8</sup>Heidi Garrett-Peltier, “Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model,” *Economic Modelling*, Elsevier, vol. 61(C), 439–47.

#### Exhibit 1

### Nearly two-thirds of survey respondents say governments' economic-recovery efforts after COVID-19 should prioritize climate change.

**Government actions should prioritize climate change in the economic recovery after COVID-19,**  
% of respondents<sup>1</sup>



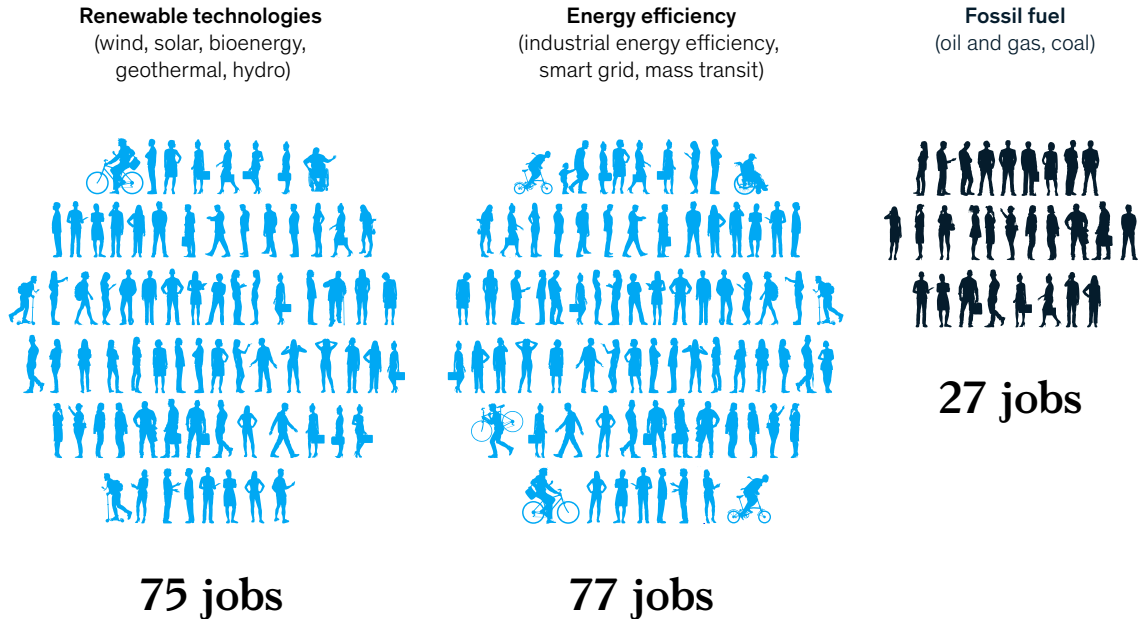
<sup>1</sup>Question: “To what extent do you agree or disagree with the following: In the economic recovery after COVID-19, it’s important that government actions prioritize climate change.” Response rates shown for “agree” include “strongly agree” and “somewhat agree”; rates for “disagree” include “strongly disagree” and “somewhat disagree.” Survey conducted via online poll, April 17–19, 2020; n = 28,039; data are weighted to the profile of the population.

Source: Ipsos MORI

## Exhibit 2

### Government spending on renewable energy and energy efficiency has been shown to create more jobs than spending on fossil fuels.

Jobs created, directly and indirectly,<sup>1</sup> per \$10 million in spending



<sup>1</sup>Excludes induced jobs.

Source: Heidi Garrett-Peltier, "Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model," *Economic Modelling*, pp. 439–47, 2017

### How to design and implement low-carbon stimulus programs

In assessing stimulus measures, policy makers may wish to balance several factors, such as socioeconomic benefits, climate benefits, and feasibility, before turning to implementation.

#### Identifying and prioritizing low-carbon stimulus options

To add climate change to post-crisis stimulus planning, policy makers might pay attention to a wide range of considerations as they evaluate programs that might receive public funds:

**Socioeconomic benefits.** These can be assessed by various criteria, including the number of jobs created per sum of money spent, the GDP or gross-value-added (GVA) multiplier, or the benefits to particular population segments, sectors, or geographies. The last consideration may be

especially important, for COVID-19's economic fallout has landed unevenly. A McKinsey analysis of the United Kingdom and the United States shows that less-skilled workers, younger workers, lower-paid workers, and racial and ethnic minorities hold disproportionately large shares of jobs made vulnerable by lockdowns.<sup>9</sup>

Other areas to consider include regions and demographics affected by the low-carbon transition—for example, those exposed to phaseouts of coal mining and fossil-fuel power generation.

**Climate benefits.** A stimulus measure's decarbonization effect can be gauged by tons of greenhouse gases prevented (or removed) per year or by the ability to enable other carbon-reducing changes. Reinforcing the energy grid, for example, promotes more distributed microgeneration, which can cut emissions.

<sup>9</sup>Tera Allas, Marc Canal, and Vivian Hunt, "COVID-19 in the United Kingdom: Assessing jobs at risk and the impact on people and places," May 11, 2020, McKinsey.com.

### Time frame for economic stimulus to take effect.

Certain measures have a more immediate effect on job creation and GDP growth; for example, programs to construct bicycle lanes can ramp up and create jobs quickly. Other options take longer to play out. Big infrastructure projects require extensive planning before economic activity starts in earnest.

### Time frame in which carbon emissions are reduced.

Some stimulus measures, such as efforts to improve industrial efficiency, can lower emissions in the near term. Measures to support the development of low-carbon technologies, such as advanced batteries or carbon capture and storage (CCS), may take longer to make a difference. But that difference can become enormous when such technologies are deployed widely, as we have seen with solar power, wind power, and battery storage. The cumulative decarbonization benefits of advanced technologies can make investments in innovation a valuable element of economic-stimulus portfolios.

**Feasibility.** The ease of implementing stimulus measures also matters. Construction programs, for instance, might require training or reskilling large numbers of workers. Expansions of renewable-energy capacity might proceed slowly until regional supply chains are more developed. COVID-19 also

introduces new feasibility issues, such as the need to maintain physical distancing.

All these factors matter not only when governments assess individual stimulus options but also when they assemble them into a stimulus package. Options that quickly put people to work might be attractive, but not all boost employment for long. Sustained growth might call for projects that create jobs for years to come, even if they require extra time to ramp up. A mix may provide the best employment outcomes. Similarly, policy makers might combine some measures that cut greenhouse-gas emissions in the near term with others that reduce them after several years.

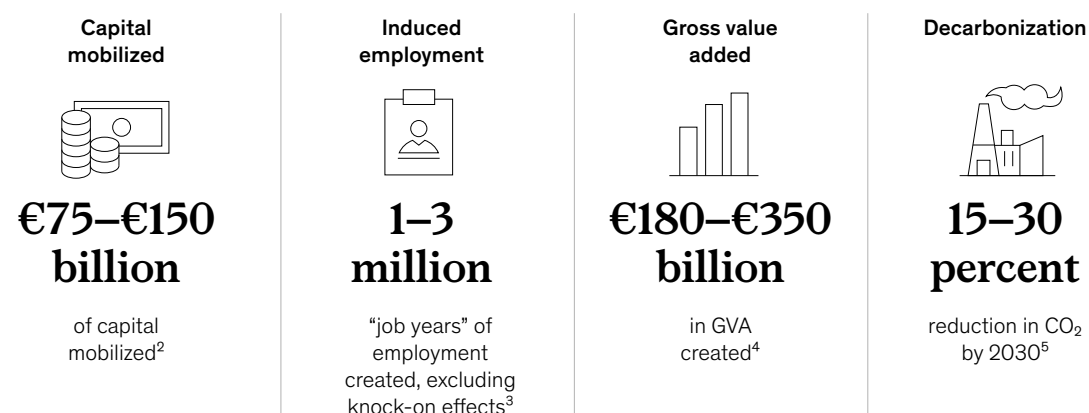
### Creating a low-carbon stimulus program: A European example

Our analysis of stimulus options across four sectors in one European country illustrates the possibility of assembling a balanced, effective low-carbon stimulus program. By our estimates, deploying €75 billion to €150 billion would produce €180 billion to €350 billion of gross value added, create up to three million new jobs—many in sectors and demographic categories where jobs are highly vulnerable—and support a 15 to 30 percent reduction in carbon emissions by 2030 (Exhibit 3).

Exhibit 3

## A balanced low-carbon stimulus portfolio can produce significant economic and environmental benefits.

### Estimated capital mobilized and impact of a low-carbon stimulus package for a European country<sup>1</sup>



<sup>1</sup> Population of 50 million to 70 million. Low-carbon stimulus package includes 12 stimulus measures.

<sup>2</sup> Includes direct government spend and “crowded-in” private-sector capital; exact cost to state is dependent on funding mechanism.

<sup>3</sup> Job years correspond to 1 job for 1 year; job multipliers measure only employment created during spend. In practice, economic stimulus could create jobs that become self-sustaining, resulting in more job years than shown here.

<sup>4</sup> Based on gross-value-added multiplier at a sector level for a typical European country of 50 million to 70 million people.

<sup>5</sup> Reduction is relative to current emissions and estimated based on potential; actual reduction will depend on multiple societal factors.

These outcomes rest on a careful selection of stimulus measures from an initial menu of nearly 50 options. We based estimates of the GVA multipliers of each potential measure on those observed for similar activities in major EU economies. Job-creation potential was estimated through a regression analysis that considered direct, indirect, and induced employment with respect to the features of various economic activities. (Since it is difficult to be precise when making such estimates, we have given them as wide ranges.)

To gauge each measure's decarbonization impact, feasibility, and fit with the skills of the workforce and the needs of individual sectors, we drew on expert interviews and academic research.

This approach yielded a list of 12 feasible stimulus measures with strong socioeconomic benefits (including multiregional job creation) and decarbonization effects in the near, medium, and long terms (Exhibit 4):

Exhibit 4

### Analysis highlights 12 low-carbon stimulus measures with strong socio-economic and decarbonization benefits.

#### Estimated capital mobilized and impact of low-carbon stimulus measures for a European country<sup>1</sup>

Stimulus measure by sector	Capital mobilized, <sup>2</sup> € billion	Jobs per € million, <sup>3</sup> number	Jobs created, <sup>3</sup> thousand	GVA created, <sup>4</sup> € billion	GVA multiplier
<b>Industry</b>					
Improve industrial energy efficiency	1–5	~14–20	15–100	2–11	2.1
Build carbon-capture-and-storage infrastructure	1–4	~15–20	30–80	4–9	2.2
<b>Buildings</b>					
Retrofit houses for energy efficiency <sup>5</sup>	50–80	~16–21	800–1,700	110–180	2.2
Install smart-building systems	0.1–2.0	~14–19	2–40	0.2–4.0	1.9
<b>Energy</b>					
Reinforce the electricity-distribution grid	5–10	~15–20	75–200	10–22	2.2
Expand energy storage	1–5	~14–19	15–95	3–18	3.4
Accelerate build-out of wind and solar power	10–20	~13–18	130–360	35–70	3.4
Accelerate rollout of LED street lighting	0.1–0.2	~15–21	2–5	0.2–0.4	2.2
<b>Transport</b>					
Expand electric-vehicle charging networks	3–5	~13–18	40–90	6–10	1.9
Create bus rapid transit and urban rail schemes	2–8	~20–25	40–200	4–18	2.2
Scale up electric-vehicle manufacturing	1–2	~14–19	20–40	2–4	2.1
Develop active-transport infrastructure <sup>6</sup>	0.5–5.0	~20–25	10–130	1–10	2.2

<sup>1</sup>Population of 50 million to 70 million. <sup>2</sup>Includes direct government spend and "crowded-in" private-sector capital; exact cost to state dependent on funding mechanism. <sup>3</sup>Estimated related to main economic activity based on OECD country data and McKinsey analysis, includes direct, indirect, and induced jobs. Job years correspond to 1 job for 1 year; job multipliers measure only employment created during spend. In practice, economic stimulus could create jobs that become self-sustaining, resulting in more job years than shown here. <sup>4</sup>Based on gross-value-added (GVA) multiplier at a sector level for a typical European country of 50 million to 70 million people. <sup>5</sup>Estimate of deep retrofit (including heat pumps) of 2 million homes. Exact quantity of homes highly flexible. <sup>6</sup>For example, bicycle lanes.

- Improve industrial energy efficiency through such means as replacing equipment and upgrading waste-heat technologies
- Build carbon-capture-and-storage infrastructure around large industrial clusters
- Retrofit houses to increase energy efficiency—for example, by installing heat pumps
- Install smart-building systems, particularly in commercial property, to better manage heating, ventilation, air conditioning, lighting, and security
- Reinforce the electricity-distribution grid (including interconnections) to support widespread electrification
- Expand large- and community-scale energy storage
- Accelerate the build-out of wind- and solar-power generation capacity
- Accelerate the rollout of street lights using light-emitting diodes (LEDs)
- Expand electric-vehicle (EV) charging networks
- Create major bus rapid transit and urban rail projects
- Scale up EV manufacturing
- Develop infrastructure for active transport (such as bicycling lanes)

According to our analysis, this stimulus package would deliver substantial economic and environmental returns. For this example, we assumed that the capital mobilized would range from €75 billion to €150 billion. The exact cost to a government would depend on how the

measures were funded—for instance, whether the government invested directly or private-sector capital provided some funding. In any case, we estimate that half of the money would be spent in the first two years and the vast majority within five. Our analysis suggests that every €1 spent would generate some €2 to €3 of GVA.

The employment boost from this stimulus package would also be substantial: 1.1 million to 1.5 million new “job years” of employment at the low end of the spending range and 2.3 million to 3.0 million at the high end.<sup>10</sup> These are conservative estimates, accounting only for jobs created as money is disbursed; additional self-sustaining employment could also be created. By design, most of the jobs would be low- or medium-skill jobs, for which demand will be greatest, and many are in sectors (for example, industry) that have large numbers of jobs at risk. Some are in categories with enough labor flexibility to concentrate hiring in regions with the highest unemployment rates. Hiring for these stimulus measures would begin on a range of dates, from the near term to the medium to long term.

All of this spending and labor ought to help the country’s transition to a low-carbon economy move forward. By our estimates, these measures could help cut CO<sub>2</sub> emissions 15 to 30 percent, from current levels, by 2030. Such a decrease would account for a good portion of the 50 percent emissions reduction that is considered necessary to achieve a 1.5°C warming pathway by 2030.

### **Implementing low-carbon stimulus measures**

Policy makers can use various mechanisms to deliver stimulus measures. We classify these in two main groups: pushes and pulls. Pushes are regulatory interventions or backstops that give companies more certainty about future regulations and thereby encourage forward planning. Building codes are one kind of push, target dates for phasing out technologies another.

<sup>10</sup>Job years correspond to one job for one year.

# Many stimulus measures produce the greatest benefit if delivered through a combination of pushes and pulls.

Pulls—financial interventions that compel companies to take particular actions—generally fall into one of four main groups:

- *Tax credits and subsidies* are suited to stimulus measures targeting active markets. For example, these might help accelerate improvements in industrial energy efficiency, since many companies are making them and capital is available.
- *Loans and loan guarantees* tend to work best when they target a few beneficiaries, because their administrative costs are relatively high. Loans can fill gaps in private lending, and loan guarantees can bring down interest rates for projects that private lenders see as risky. Loans and loan guarantees could support EV-charging infrastructure, for example, by diminishing the risk for charging-network operators, which must make large capital outlays without knowing when EVs will become widely used.
- *Grants* can deliver stimulus funding to many parties (such as the small contractors that retrofit homes) because their administrative costs are comparatively low. They are also useful to fund projects, such as research and development, that generate no short-term revenues.

- *Direct government ownership* can be appropriate for projects that lack a revenue stream reliable enough to interest the private sector or that inspire a political interest in outright ownership. Such projects might include grid upgrades or CCS systems, depending on regulations.




In addition to direct regulatory pushes and financial pulls, policy makers can also implement indirect “nudges” of both kinds, such as high-occupancy vehicle lanes. At modest cost, these nudges can complement and reinforce more direct measures.

Many stimulus measures produce the greatest benefit if delivered through a combination of pushes and pulls (Exhibit 5). Since stimulus packages often target a variety of companies, policy makers can create delivery mechanisms that allow wide access to funds by designing each measure to reach its intended beneficiaries. CCS network build-outs, for example, could require negotiations with just a few companies, while home retrofit programs might engage thousands of small businesses. The sequencing of pulls and pushes can also make a big difference. To foster new hiring and growth before regulations begin to restrict certain economic activities, policy makers might consider funding ahead of new regulations.

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Exhibit 5

## Some stimulus projects can be more effective if delivered using a balanced combination of mechanisms.

Illustrative examples		The push (regulation)		The pull (funding)
<b>Building energy efficiency</b>		Require residential properties to have a certain minimum energy rating, (eg, when renting or selling the property) and ban the use of oil boilers from a targeted date	+	Provide direct funding to retrofit residential property (eg, grants for heat pumps)
<b>Electric vehicles</b>		Restrict the use of internal-combustion-engine vehicles in urban areas (eg, with clean-air zones)	+	Introduce substantial tax breaks for the installation of electric-vehicle charging stations
<b>Carbon capture and storage (CCS)</b>		Mandate that industrial emitters over a certain threshold in specific regions adopt CCS technologies	+	Fund CCS infrastructure (eg, storage and transport network) in major industrial hubs

It now appears that recovery from the COVID-19 economic crisis will require stimulus programs lasting for months or even years. Those coming months and years will also be a decisive time for efforts to keep global warming within 1.5°C to 2°C. Low-carbon stimulus measures can help policy

makers fulfill both needs at once—but the clock is ticking. This is the pivotal moment for policy makers to unite their economic and environmental priorities to improve and sustain the well-being of individual citizens and of the planet as a whole.

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# Water: A human and business priority

Water stress increases risk for communities and businesses. Through proactive individual and collective action, businesses can combat the water crisis.

*by Thomas Hundertmark, Kun Lueck, and Brent Packer*



**Water is the lifeblood** of humanity. With it, communities thrive. But, when the supply and demand of fresh water are misaligned, the delicate environmental, social, and financial ecosystems on which we all rely are at risk. Climate change, demographic shifts, and explosive economic growth all exacerbate existing water issues.

However, hope is not lost. Businesses can play a leading role in mitigating the water issue to limit not just their own risk but also the risk of all stakeholders relying on these systems. This can be accomplished by directing action through three spheres of influence: direct operations, supply chain, and wider basin health.

## Water today

Water is as important to the world's economy as oil or data. Though most of the planet is covered in water, more than 97 percent of it is salt water. Fresh water accounts for the rest, although most of it is frozen in glaciers, leaving less than 1 percent of the world's water available to support human and ecological processes. Every year, we withdraw 4.3 trillion cubic meters of fresh water from the planet's water basins. We use it in agriculture (which accounts for 70 percent of the withdrawals), industry (19 percent), and households (11 percent).

These percentages vary widely across the globe. In the United States, industrial usage (37 percent) is almost as high as agricultural (40 percent); in India, on the other hand, agriculture claims 90 percent of water withdrawals, while only 2 percent is put to work for industry. China's withdrawals are 65 percent agriculture, 22 percent industrial, and 13 percent for household use. Considering that some of the agricultural usage is directed toward industry—for example, half of the production of maize, which is one of the top five global crops by total acreage and water consumption, is used for producing ethanol—the figures may understate how critical water is to business.

All industries rely on water in some way. A company's water footprint can be seen in four key areas of its value chain: raw materials, suppliers, direct operations, and product use. Consider, for example, a T-shirt across its value chain—raw materials

(cotton), suppliers (cotton-to-fabric processor), direct operations (final manufacturing, shipping, and retail), and product use (washing the shirt at home). Food and beverage companies use water as an ingredient in the products they sell, of course, but they also use it to irrigate, rinse, and clean crops, and to feed livestock. Metals and mining companies need water for dust control, drilling, and slurry when transporting products. In the tech industry, suppliers require ultrapure water for certain manufacturing processes, and data centers require water for cooling. Forest-products companies rely on water for making pulp and paper. Apparel companies rely on water to grow raw materials and wash garments. Even insurance companies are affected by water through claims related to water, such as crop-production insurance. Water's uses and effects are as varied as business itself.

The availability of fresh water also varies greatly by location. The majority of the world's fresh water is divided among 410 named basins, which are areas of land where all water that falls or flows through that region ultimately ends at a single source. These include the Huang He, Nile, Colorado River, Indus, and many others. Of these 410 named basins, almost a quarter (90) are considered "high stressed" (meaning that their ratio of total annual withdrawals to total available annual supply exceeds 40 percent). These 90 highly stressed basins account for just 13 percent of the total area of named water basins but account for 51 percent of withdrawals (Exhibit 1). About half are located in three countries with enormous water needs and high economic activity: China, India, and the United States.

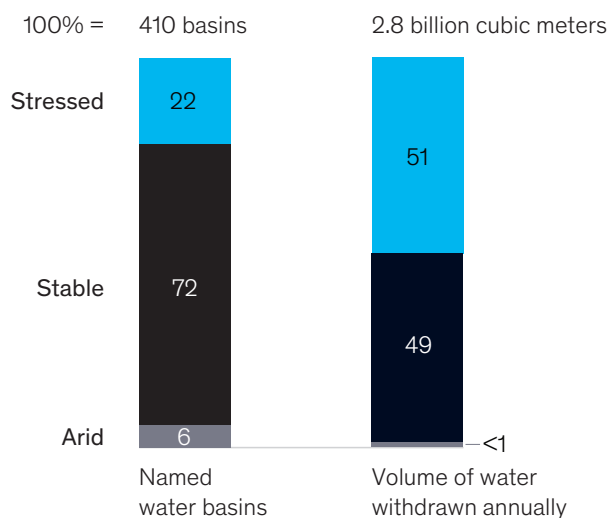
## The water crisis is here, and it's getting worse

Water risk is not a worry to be addressed in some nebulous future. The supply of fresh water has been steadily decreasing while demand has been steadily rising. In the 20th century, the world's population quadrupled—but water use increased sixfold. The strain is already apparent. In 2018, in the midst of a severe drought, Cape Town, South Africa, came close to experiencing a so-called Day Zero, where the city would have literally run out of water. To avoid that peril, the city government put quotas on agricultural, business, and domestic usage. The

Exhibit 1

## Much of the world's water supply is drawn from stressed water basins.

% of named<sup>1</sup> basins and withdrawals by stress level<sup>2</sup>



<sup>1</sup>"Named" basins are the world's most significant basins. About 1.3 billion cubic meters of water are withdrawn annually from smaller, unnamed basins.

<sup>2</sup>A basin is considered stressed when the ratio of total annual withdrawals to total available annual supply exceeds 40 percent.

Source: World Resources Institute

government also got lucky: rain replenished its basin just in time. All in all, the drought drove at least 5.9 billion rand (approximately \$400 million) in economic losses across the Western Cape.

This event, and others like it, are just a taste of what's to come. As McKinsey's 2009 report *Charting our water future: Economic frameworks to inform decision-making* made clear, climate change, population growth, and changing consumer habits are increasing water stress for many regions.<sup>1</sup> The recent McKinsey Global Institute report *Climate risk and response: Physical hazards and socioeconomic impacts* notes that many of the world's basins could see a supply decline of around 10 percent by 2030 and up to 25 percent by 2050.<sup>2</sup> By 2050, according to UN estimates, one in four people may live in a country affected by chronic shortages of fresh water. The World Bank estimates that the crisis could slow GDP by 6 percent in some countries by 2050 as well.

Water stress is a risk multiplier. Alone, it is a powerful risk with the potential to upend socioeconomic and ecological systems. When compounded with other risks, such as those related to food and energy systems, politics, and infrastructure, it becomes detrimental.

### The clear and increasing business risk

Two-thirds of businesses have substantial risk in direct operations or in their value chain. As water stress grows, they will experience that risk in four forms: physical, regulatory, reputational, and stakeholder.

Physical risks can be critical and costly. In some locations, key water sources may be inaccessible or unfit for use. A primary physical risk is having too little water, which can be a costly problem. A 2015 drought in Brazil drove up General Motors' water costs there by \$2.1 million, and its electricity costs rose an additional \$5.9 million.

<sup>1</sup>"Charting our water future," November 2009, McKinsey.com.

<sup>2</sup>"Climate risk and response: Physical hazards and socioeconomic impacts," McKinsey Global Institute, January 2020, McKinsey.com.

As the crisis worsens, companies may find themselves increasingly beholden to the whims of government regulators. When Chinese regulators mandated in 2015 that papermakers cut water consumption by 10 percent, Chenming Group, one of the top ten players in the global paper industry and the leading player in the Chinese market, responded by upgrading its assembly line with advanced equipment that reduced daily water consumption by 45 percent. In 2017, the state government of Kerala, India, facing a severe drought, restricted PepsiCo's groundwater consumption by 75 percent.

A company's pro-environment reputation is becoming increasingly critical. A 2018 Nielsen survey found that 81 percent of global customers say it is important for companies to improve the environment.<sup>3</sup> Consumers are voting with their dollars for companies that align with these principles. The same survey found that 73 percent of customers would change their purchasing habits to reduce environmental impact. In the age of single-tweet public-relations crises, the best defense is getting ahead of issues before they strike.

Stakeholder risk is rapidly growing as more companies and influential bodies become aware of the other types of business risk. These significant players are able to exert outsize influence on other businesses to nudge them toward practices that are consistent with their own sustainability and business ethos. BlackRock CEO Larry Fink cited water risk in his 2020 letter to CEOs, stating, "What happens to inflation, and in turn interest rates, if the cost of food climbs from drought and flooding?" BlackRock, which has nearly \$7 trillion in assets under management, was a founding member of the Task Force on Climate-related Financial Disclosures (TCFD) and is engaging with the companies it invests in to ensure that they follow these guidelines. Moreover, BlackRock is working internally to continually improve the standards of its own reporting in this domain as well. In addition to BlackRock, more than 600 other investment firms with \$69 trillion in total assets under management now urge their companies to report on water-related risks and act to mitigate them. (For more, see "'Bring the problem forward': Larry Fink on climate risk," on McKinsey.com.)

## How businesses can tackle the problem

The water issue is the reverse of the carbon problem; the cause is global, but its manifestation is highly spatial and can be addressed in a concentrated way. Not all basins have equal priority. In fact, several basins have water withdrawals that are well within sustainable limits. Rather than tackling water use across every geography, a more efficient route is for companies to understand how they are interacting with basins that are projected to become water stressed and focus efforts there. Apple, for example, anchors its water stewardship policies by mapping its global water use against regions with heightened water risk. As a result, it focuses its efforts on three regions accounting for 52 percent of its total water use: Maiden, North Carolina; Mesa, Arizona; and Santa Clara Valley, California.

There are three spheres of influence that companies can affect to help mitigate water stress: direct operations, supply chain, and wider basin health. Some companies are already taking action in all three areas.

### Direct operations

Within their four walls, companies have several levers they can use to reduce water stress. They can implement water measurement and reporting practices, even including water use in relevant company key performance indicators (KPIs). They can aggressively identify and eliminate water leaks in their operations and introduce new technologies that reduce water stress.

In 2010, Ford set a goal of using 30 percent less water per car by 2014. It reached that goal through a combination of new KPIs and operational improvements. The introduction of internal water metering alone drove conservation behaviors to the department level and helped save around \$5 million worldwide. A dry-paint-spray system eliminated water from the car-painting process, and a new lubricant that replaced water in the manufacturing process saved about 280,000 gallons per production line.

Colgate-Palmolive partnered with a water-technology company to meet its sustainability goals

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<sup>3</sup> "Unpacking the sustainability landscape," Nielsen, November 9, 2018, [nielsen.com](https://www.nielsen.com).

for a plant located in a water-scarce basin in Mexico. Its processes require a significant amount of water to ensure proper sanitation for the toothpaste, deodorant, and soap products produced. The new solutions were able to reduce the plant's water use by 1.8 million gallons annually while also significantly reducing the amount of time required for cleaning and sanitizing.

### **Supply chain**

Companies can further reduce water stress by using their influence to ensure that their suppliers and their suppliers' suppliers are equally rigorous about their own contributions to water stress. There are three critical levers to pull: reducing energy use and shifting to renewables, setting supplier standards, and sending water-expert teams to help key suppliers identify and implement efficient water-usage solutions.

Water is required to both extract many energy sources and generate energy through steam-powered turbines. The reduction of energy consumption and the market shift toward renewable sources has the dual effect of lowering greenhouse-gas emissions and reducing water withdrawals. With the transition to a more decarbonized world, new energy-investment decisions can consider water benefits alongside carbon, cost, reliability, and other lenses. The production and use of fossil fuels requires up to four times more water than the production of renewables. If the future energy mix of the planet remains the same as it is now, withdrawals from water basins for energy can grow by 25 percent by 2040. On the other hand, switching 75 percent of fossil-fuel consumption to

renewables by that time, per individual countries' Paris Agreement targets, can reduce the water footprint of energy by 47 percent (Exhibit 2).

Companies can also set reporting standards for suppliers. In 2014, Levi Strauss launched a Recycle & Reuse compliance program, which requires that each supplier meet certain limits; use a blend of at least 20 percent recycled water in its facility processing, landscaping, cooling, and plumbing; and provide flow-meter data that tracks the amount of recycled water used on Levi Strauss products.

Nike has successfully implemented a water-supplier initiative, which the company refers to as the Minimum Water Program. Teams work closely with the company's largest materials suppliers and others to ensure good water practices by offering their own expertise to assist their suppliers. The program has been a success—in 2019, Nike achieved its initial goal of reducing fresh water used in textile dyeing by 20 percent, 18 months ahead of schedule.

### **Wider basin health**

Some businesses may choose to go further by using their influence in partnerships that promote water resilience.

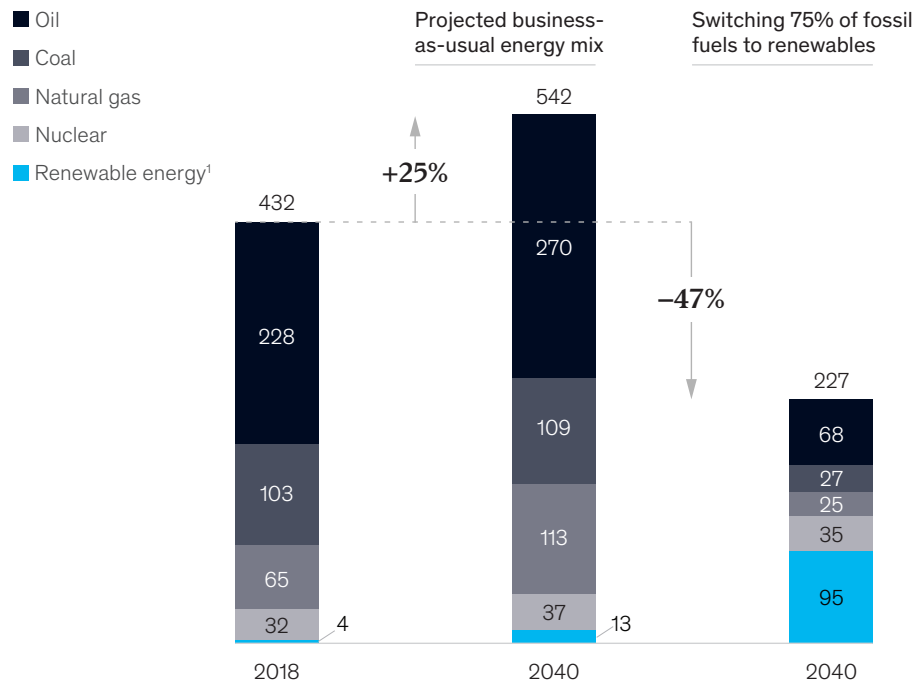
During the United Nations' 2012 Conference on Sustainable Development, 45 of the world's largest companies united to advocate for governments to implement sensible water policies. The companies (including Bayer, Coca-Cola, GlaxoSmithKline, Merck, and Nestlé) signed a special communiqué demanding that governments raise the price of water to a fair and appropriate price. The companies committed

**The reduction of energy consumption and the market shift toward renewable sources has the dual effect of lowering greenhouse-gas emissions and reducing water withdrawals.**

## Exhibit 2

### Shifting to renewables would save water.

Total water footprint for energy production globally, billion cubic meters



<sup>1</sup> Includes solar, wind, hydro, and biodiesel.

Source: International Energy Agency; James Meldrum et al., "Life water cycle use for electricity generation: A review and harmonization of literature estimates," *Environmental Research Letters*, March 2013, Volume 8, Number 1; Edward Spang et al., "The water consumption of energy production: An international comparison," *Environmental Research Letters*, October 2014, Volume 9, Number 10; US Energy Information Administration

to ongoing lobbying to support water-positive policies, such as a fair market price for water. Without price increases, water users do not have feedback mechanisms that incentivize conservation and the development of new technologies to cut usage.

Another significant initiative is the Water Resilience Coalition, a creation of the UN Global Compact's CEO

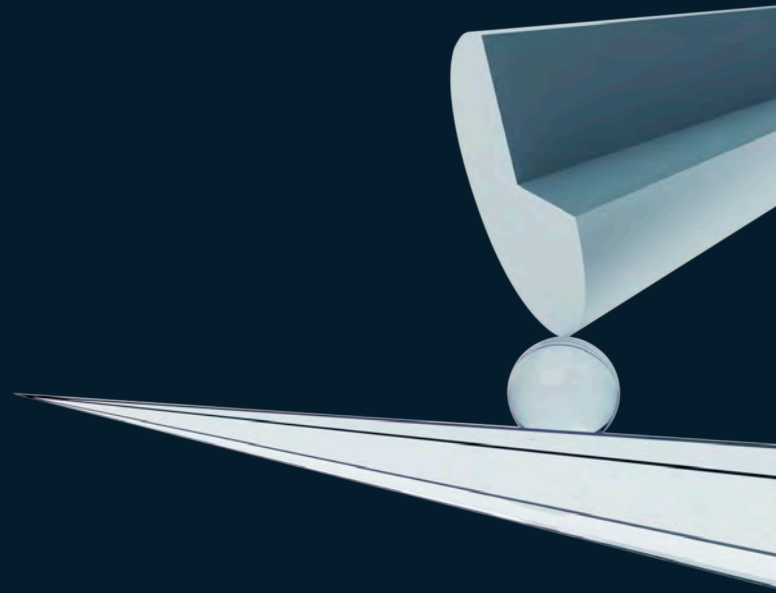
Water Mandate. Launched in March 2020, it is built around a water-resilience pledge that binds signatory companies to a set of water goals to be addressed by collective action in water-stressed basins.

As with other key components of climate change, the time has come to address the water crisis head-on. Businesses have a key role to play.

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# Measuring the business value

**48**

The ESG premium: New perspectives on value and performance

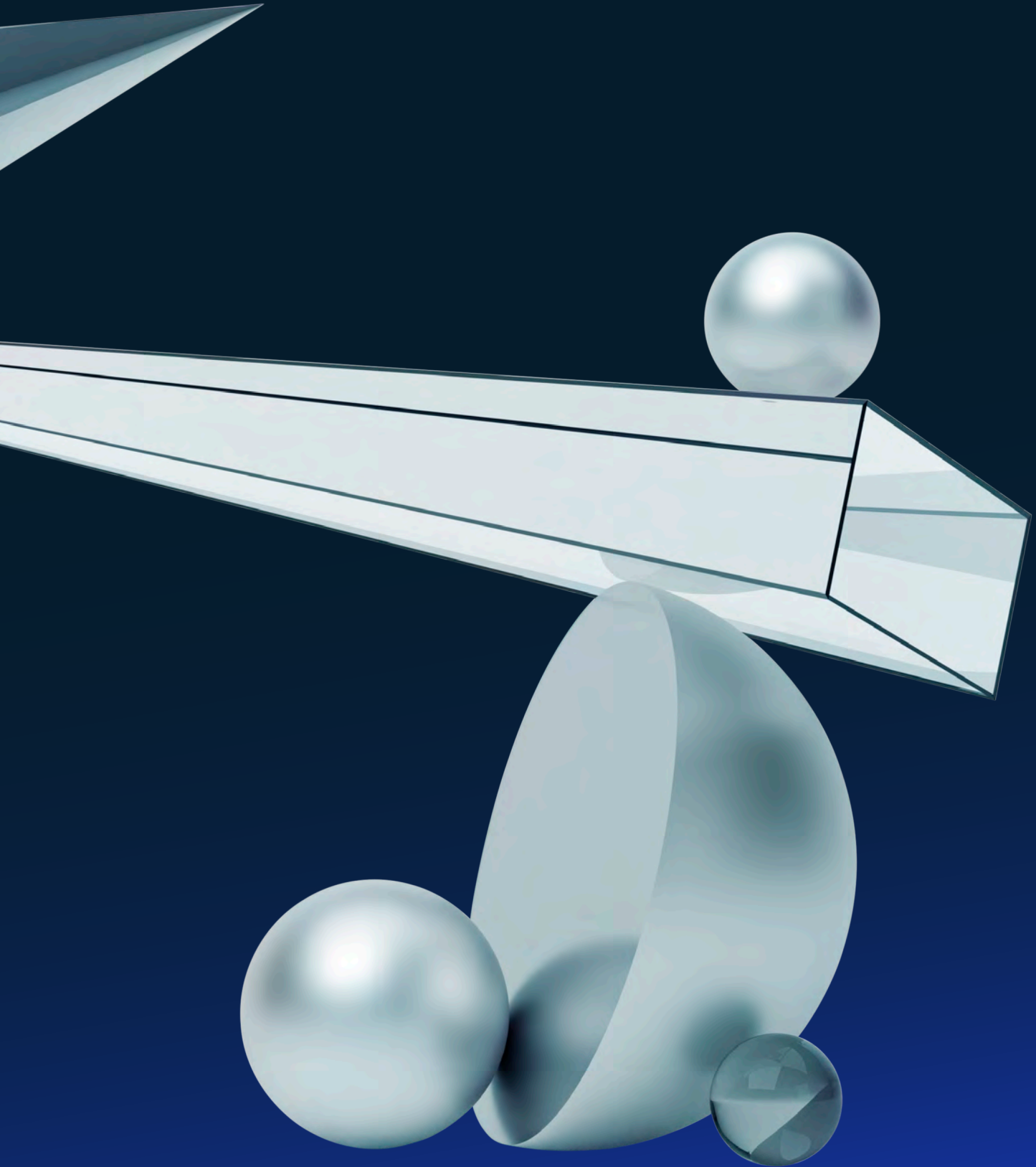
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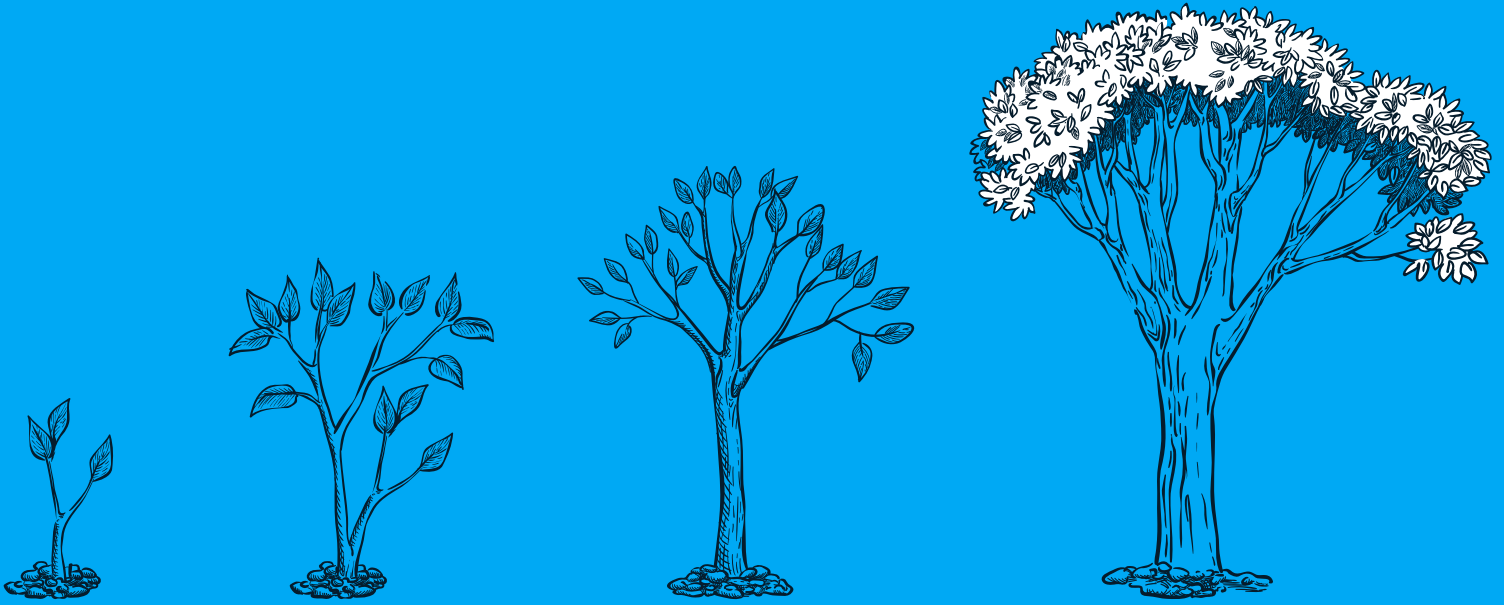
Earth to CEO: Your company is already at risk from climate change

**60**

More than values: The value-based sustainability reporting that investors want







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# The ESG premium: New perspectives on value and performance

In a new survey, executives and investment professionals largely agree that environmental, social, and governance programs create short- and long-term value—though perceptions of how have changed over the past decade.

**Pressure on companies** to pay attention to environmental, social, and governance (ESG) issues continues to mount. Researchers, business groups, and nongovernmental organizations have variously warned of the risks—or emphasized the opportunities—that such issues present to company performance.<sup>1</sup> Most executives and the investment professionals who scrutinize their companies seem to agree that ESG programs affect performance. In our latest McKinsey Global Survey on valuing ESG programs,<sup>2</sup> 83 percent of C-suite leaders and investment professionals say they expect that ESG programs will contribute more shareholder value in five years than today. They also indicate that they would be willing to pay about a 10 percent median premium to acquire a company with a positive record for ESG issues over one with a negative record. That's true even of executives who say ESG programs have no effect on shareholder value.

Among respondents who say that such programs increase shareholder value, perceptions of how the programs do so have shifted since our survey on the subject in 2009.<sup>3</sup> A majority of these business leaders and investment professionals now say that environmental, social, and governance programs individually create value over both the short term and the long term. Moreover, the perceived long-term value of environmental and social programs now rivals or exceeds the value attributed to governance programs.

What follows is a closer look at how perspectives have changed with respect to several topics, including the impact of ESG on shareholder value and financial performance, the reasons companies prioritize ESG programs, and the challenges and opportunities in ESG data and reporting.

## ESG programs and shareholder value

A majority of surveyed executives and investment professionals (57 percent) agree that ESG programs create shareholder value. That share is largely consistent with responses to the survey a decade ago, as well as across most demographic categories—job title, company size, company ownership (public or private), and geography—in the present survey. Respondents in consumer-focused companies are more likely (66 percent) than those in B2B companies (56 percent) to say these programs create value.

A small minority remains unconvinced. Just 3 percent of respondents believe such programs reduce shareholder value, and 14 percent say they are unsure. That level of uncertainty is significantly lower than the 25 percent of respondents who were uncertain in 2009, but the shift corresponds to an increase in the proportion of respondents who say ESG programs have no effect on shareholder value—now at 25 percent, up from 14 percent in 2009. Much of this increase is due to the higher proportion of investment professionals reporting that the programs have no effect.

These findings come as 58 percent of respondents tell us the current political environment has increased the importance of ESG programs to meet stakeholder expectations. In addition, about four in ten say the political environment has increased the importance of ESG programs to shareholder value.

Among respondents who say that ESG programs add value, perspectives have shifted since 2009 (Exhibit 1). The survey asked separately about environmental, social, and governance programs over the long and short term. For each type of

<sup>1</sup> "Statement on the purpose of a corporation," Business Roundtable, August 2019, [opportunity.businessroundtable.org](https://opportunity.businessroundtable.org); *Community development innovation review: Strategies to address climate change risk in low- and moderate-income communities*, October 2019, Volume 14, Number 1, [frbsf.org](https://frbsf.org); *Report of the Secretary-General on the 2019 Climate Action Summit and the way forward in 2020*, United Nations, December 11, 2019, [un.org](https://un.org).

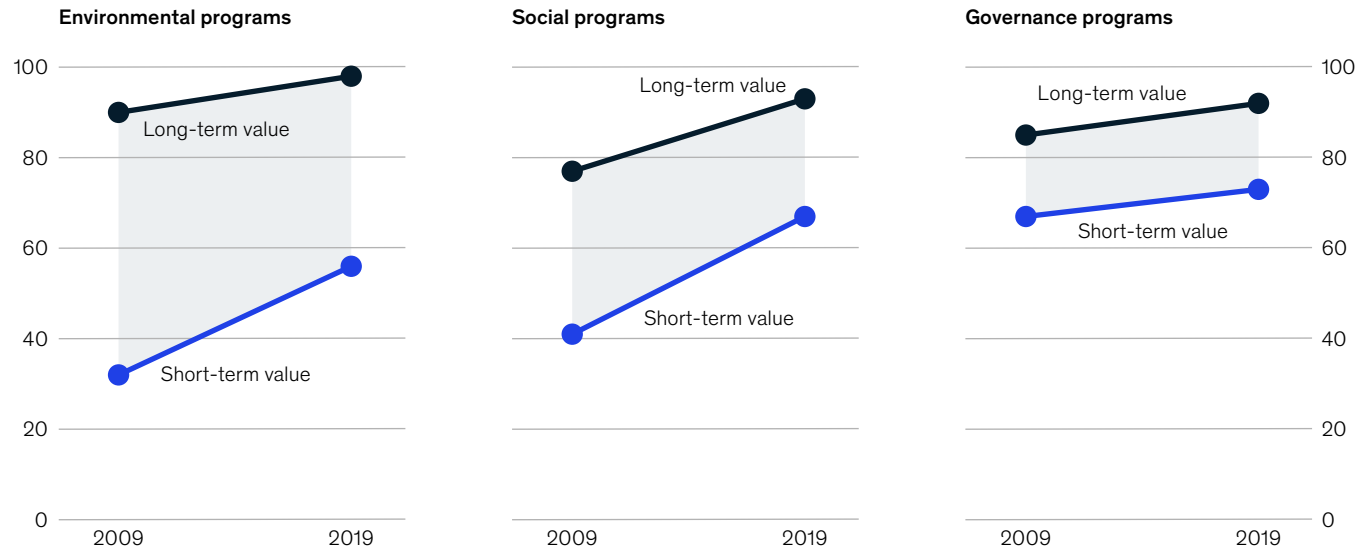
<sup>2</sup> The online survey was in the field from July 16 to July 31, 2019, and garnered responses from 558 participants representing the full range of regions, industries, and company sizes. Of these respondents, 439 are C-suite executives and 119 are investment professionals. To adjust for differences in response rates, the data are weighted by the contribution of each respondent's nation to global GDP.

<sup>3</sup> "Valuing corporate social responsibility," February 2009, [McKinsey.com](https://mckinsey.com). The 2009 survey garnered responses from 238 participants. Of these respondents, 84 were CFOs and 154 were investment professionals. Given the relative novelty of environmental, social, and governance (ESG) issues in 2009, that survey sample included only CFOs as the executives most likely to be familiar with the practice of ESG valuation. That is no longer the case. As a result, the 2019 survey sample also included CEOs, COOs, and other C-level executives with responsibility for sustainability or corporate social responsibility. All of the reported comparisons between the 2009 and 2019 data remained directionally consistent when controlling for the difference in the samples, and all but two were statistically significant; those instances are marked.

Exhibit 1

## Among respondents who say ESG programs create value, the share seeing short- and long-term value has grown.

Share of respondents who say given program creates value, %<sup>1</sup>



<sup>1</sup> Question was asked only of respondents who said environmental, social, and governance programs increase shareholder value. Respondents who said "substantially negative," "negative," or "no effect" are not shown; total n = 136 in 2009 and n = 342 in 2019.

program and each time horizon, the proportion of these respondents perceiving value creation has increased, with the greatest increases seen in social programs. Respondents are likelier to say each type of program contributes long-term value than short-term value, as was true in 2009—which may reflect the initial costs associated with investing in some ESG programs.

Respondents who say that ESG programs add value are now nearly unanimous in perceiving long-term value from environmental programs. Social and governance programs approach the same levels, with 93 percent saying social programs make a positive long-term contribution, compared with 77 percent in 2009. Similarly, the share of executives saying governance programs have positive long-term contributions has grown since the previous survey. Now executives are about as likely as investment professionals (about 90 percent of each) to say governance programs have a positive long-term contribution, which was not true in the previous survey.

Among respondents who see value from ESG programs, a majority now say these programs add shareholder value in the short term. Two-thirds of these respondents say social programs add value in the short term, up from 41 percent ten years ago. Just over seven in ten say governance programs have a positive short-term effect, compared with 67 percent who said so previously.<sup>4</sup> Since 2009, the proportion of investment professionals who report a positive impact from governance programs has held steady, and now they and executives are about equally likely to say the programs have a positive short-term impact.

Whether or not respondents believe ESG programs create value today, their expectations of future value are reflected in how they account for a positive ESG track record when comparing hypothetical M&A deals. Given a hypothetical opportunity to acquire a new business, respondents across the spectrum say they would be willing to pay about a 10 percent premium for a company with an overall positive record on ESG issues over a company with an

<sup>4</sup> This difference was not statistically significant when controlling for the different roles included in the 2009 and 2019 survey samples.

overall negative record. That median value is relatively consistent between CEOs and other C-level executives, as well as among respondents with various office locations and company focuses, sizes, and ownership structures.

The distribution of responses was wide, however. Some pockets of respondents anticipate extraordinary value from positive records on ESG. One-quarter of respondents say they would be willing to pay a premium of 20 to 50 percent, and 7 percent say they would pay a premium of more than 50 percent.<sup>5</sup> Even those who say ESG programs don't increase shareholder value are willing to pay 10 percent more for a company with a positive record, while the median among those who say ESG programs increase value for shareholders is a premium of 15 percent.

## ESG's contributions to financial performance

Maintaining a good corporate reputation and attracting and retaining talent continue to be cited most often as ways that ESG programs improve financial performance, though other perceptions of ESG's effects have shifted since the previous survey (Exhibit 2). Respondents who say ESG programs increase shareholder value are more likely than a decade ago to say that the top ways the programs improve financial performance include strengthening the organization's competitive position<sup>6</sup> and meeting society's expectations for good corporate behavior. In a separate question asked of respondents who say ESG programs increase shareholder value, more than half say the existence of high-performing ESG programs is a proxy for good management, in line with the 2009 findings.

<sup>5</sup> Figures were calculated after removing respondents who said "don't know/prefer not to answer" (21 percent of total responses).

<sup>6</sup> This difference was not statistically significant when controlling for the different roles included in the 2009 and 2019 survey samples.

Exhibit 2

## Perceptions have shifted in the past decade around how ESG programs contribute to financial performance.

**Top ways that ESG programs improve financial performance,**  
% of respondents<sup>1</sup>



<sup>1</sup> Question was asked only of respondents who said environmental, social, and governance programs increase shareholder value. Executives were asked which ways ESG programs improve their organizations' financial performance, and investment professionals were asked which ways ESG programs improve organizations' financial performance. Respondents who said "other" or "don't know" are not shown; total n = 136 in 2009 and n = 342 in 2019.

<sup>2</sup> Not statistically significant when controlling for the different roles included in the 2009 and 2019 survey samples.

The survey also asked all respondents which aspects of ESG-related activities are most important. The largest share cite compliance, and they are likelier to say so now than in 2009 (Exhibit 3). Respondents are less likely now than in the previous survey to identify changing business processes to incorporate good ESG practices as most important. Notably, responses among investment professionals and executives are relatively similar.

### Considering ESG factors in strategic and operational decisions

Executives and investment professionals indicate that they commonly take ESG issues into consideration when making strategic and operational decisions. More than seven in ten respondents say they—or, in the case of executives, their organizations—somewhat or fully consider ESG issues in their assessments of

a company's competitors and its supply chain. And nearly eight in ten say they at least somewhat consider ESG issues in their assessments of potential capital projects.

When asked whether they or their organizations track the impact of ESG programs on various stakeholder groups, respondents indicate that they consider a variety of stakeholders (Exhibit 4). About half of respondents report considering the impact on board directors, regulators, and investors entirely or to a great extent. Roughly one-third report considering the impact on industry peers and associations, prospective employees, and NGOs. Compared with executives, investment professionals indicate that they consider the impact of ESG programs on a far broader swath of stakeholders. While board directors are the only stakeholders that more than half of executives say their organizations consider, more than half of investment professionals say they take into

Exhibit 3

**Respondents are more likely than in 2009 to say complying with regulations and industry expectations is the most important aspect of ESG activities.**

**ESG activity ranked as most important, % of respondents<sup>1</sup>**



<sup>1</sup>Figures do not sum to 100%, because respondents who said "other" or "don't know" are not shown; total n = 238 in 2009 and n = 573 in 2019.

<sup>2</sup>For example, changes to purchasing or performance-management systems, or redesign of factory processes to minimize waste.

<sup>3</sup>That is, through charitable giving or philanthropy, product donations, and/or support for employee volunteering.

account the programs' impact on board directors, communities, investors, prospective customers, and regulators.

### A quest for meaningful ESG data and reporting

The share of all respondents saying that ESG reporting standards and frameworks are useful for interpreting ESG programs' value has increased by 15 percentage points since 2009. Nevertheless, when we asked investment professionals and executives who report that their organizations do not fully include ESG considerations in assessments of competitors, suppliers, or major capital markets why they don't do so, both groups most often say that available data are insufficient

(Exhibit 5).<sup>7</sup> Other top reasons relate to the usability of data: contributions are too indirect to value, or analytic expertise is lacking.

Not surprisingly, then, when asked to identify the most important features of ESG reporting systems, respondents most often cite quantification of the financial impact of ESG programs (53 percent) and measurement of business opportunities and risks (47 percent). The third most cited feature, noted by 40 percent of respondents, is a consistent set of industry-specific metrics. This may explain why the systems most often considered valuable by investment professionals are reporting frameworks and standards, as well as certification or accreditation standards, such as SA8000.<sup>8</sup> By contrast, indexes produced by polling, media, and PR firms are the

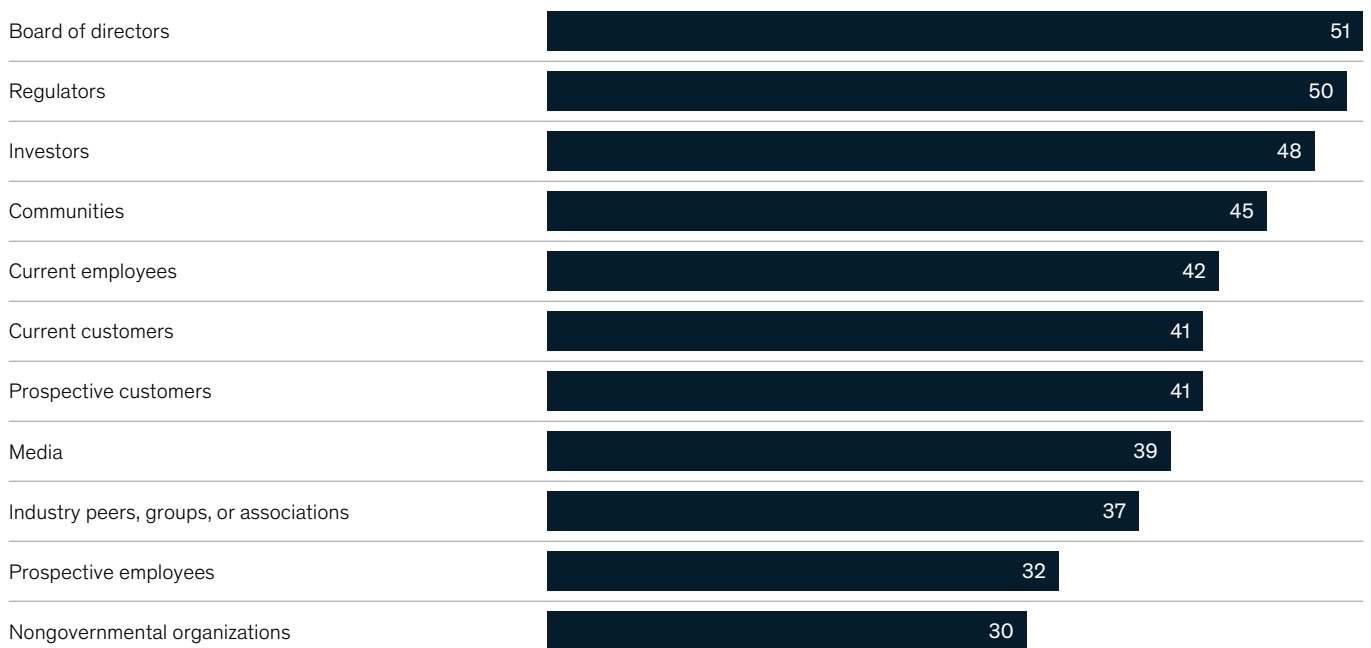
<sup>7</sup> The question was asked only of the 414 executives who say their organizations somewhat or do not include ESG considerations in their assessments of competitors, suppliers, and/or major capital projects and of the 110 investment professionals who say they do not include ESG considerations in their assessments.

<sup>8</sup> The systems presented as answer choices were indexes developed by financial-index companies; rankings and/or data on socially responsible investing; indexes produced by media, polling, or public-relations firms; brand rankings; certification or accreditation standards; reporting frameworks and standards; voluntary industry standards; and learning networks.

Exhibit 4

## Respondents consider the impact of ESG programs on a breadth of stakeholders.

Stakeholder groups considered entirely or to a great extent, % of respondents<sup>1</sup>



<sup>1</sup> Executives were asked to what extent their organizations track the impact that their environmental, social, and governance programs have on each stakeholder group, and investment professionals were asked to what extent they include in their valuations the impact that companies' ESG programs have on each stakeholder group. Respondents who said "not at all," "somewhat," and "don't know" are not shown; total n = 558.



least likely to be considered valuable; two-thirds of investment professionals say the indexes are not valuable or only somewhat valuable.

When we asked which aspects of tools would most improve communication between organizations and investors or analysts, the largest share of investment professionals cite integrated corporate reports that include corporate financial data and financial and other data on ESG programs. While half of these respondents say integrated reports would have the most impact, just one-third of executives say the same (Exhibit 6).

### Looking ahead

Executives and investment professionals today largely recognize that ESG issues can affect company performance, and the financial impact of ESG programs is likely to increase as expectations and scrutiny from investors, consumers, employees, and other stakeholders continue to grow. Even in industries that have exhibited more complicated records on ESG, taking action in these areas may

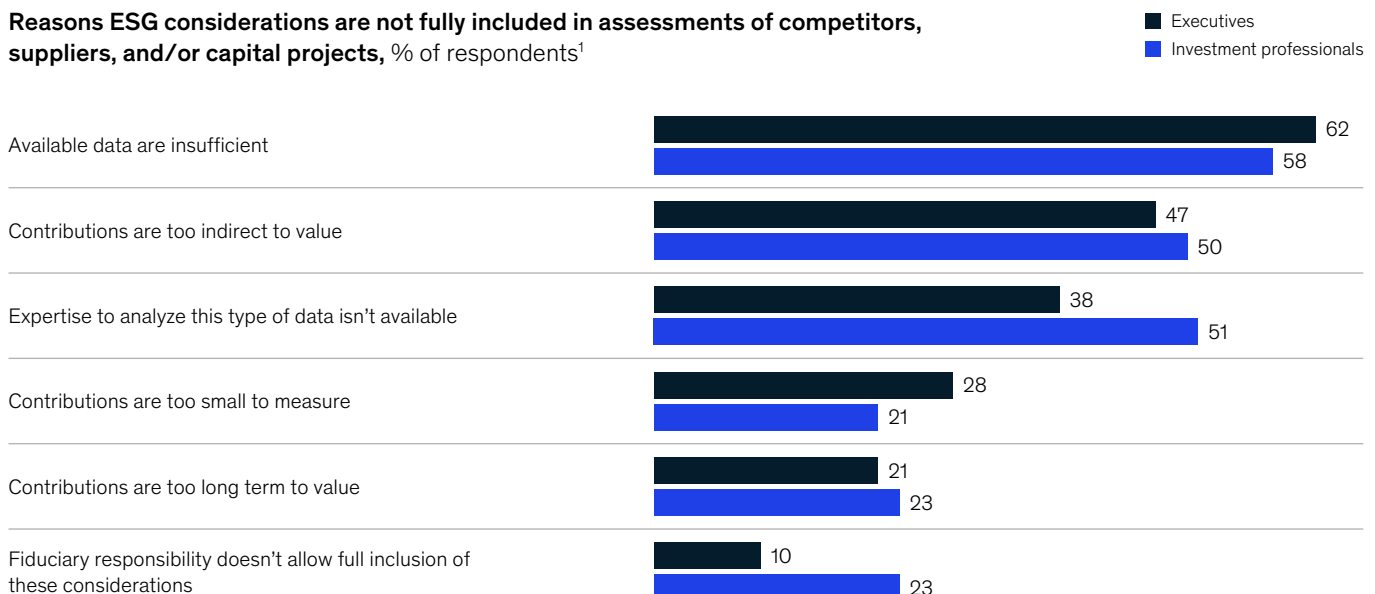
help companies navigate rising pressure from stakeholders and distinguish themselves from competitors—positioning them to create more value.

Burgeoning interest in companies' ESG performance has resulted in a proliferation of reports, rankings, requests from investors and analysts, and other mechanisms for transparency. The responses to this survey show a fairly universal desire from investors and executives to improve on the current approaches and create easier-to-use ESG metrics and data standards. It isn't possible—or worthwhile—to report on everything, but companies can focus on communicating the most critical information in ways that key stakeholders value. Investment professionals especially want ESG data that are more standard-ized, better integrated with financial data, and readily benchmarked. Such data could also benefit ESG leaders within companies, who might use the data to catalyze change internally. For example, the scenario planning required by the Task Force on Climate-Related Financial Disclosures (TCFD) standards can help with managing climate-change risks.

Exhibit 5

## Respondents largely cite data availability and usability as reasons for not considering ESG in assessments of competitors, suppliers, or capital projects.

**Reasons ESG considerations are not fully included in assessments of competitors, suppliers, and/or capital projects, % of respondents<sup>1</sup>**



<sup>1</sup>Question was asked only of executives who said their organizations somewhat or do not include environmental, social, and governance considerations in their assessments of competitors, suppliers, and/or major capital projects and of investment professionals who said they do not include ESG considerations in their assessments. Respondents who said "other" or "don't know" are not shown. For executives, n = 414; for investment professionals, n = 110.

## Exhibit 6

### Executives and investment professionals differ most on the utility of integrated reports as a tool to improve communication between them.

**Tactics that would most improve communication between organizations and investors or analysts about ESG programs' performance, % of respondents<sup>1</sup>**



<sup>1</sup> Respondents who said "other," "none of the above," or "don't know" are not shown. For executives, n = 439; for investment professionals, n = 119.

We know from previous research that strong performance on ESG issues can improve top-line growth, reduce costs, minimize regulatory and legal interventions, improve employee productivity, and focus investment and capital expenditures.<sup>9</sup> Respondents' willingness to pay a premium for companies with strong ESG performance and the belief that ESG performance is associated with

overall management quality suggest that more investors and executives will incorporate ESG into their financial and strategic decisions. If the shifts that have taken place over the past decade are a preview of the decade ahead, the value of ESG will continue to grow. Companies that have not fully committed to ESG may leave its value on the table.

<sup>9</sup> Witold Henisz, Tim Koller, and Robin Nuttall, "Five ways that ESG creates value," *McKinsey Quarterly*, November 2019, McKinsey.com.

The survey content and analysis were developed by **Lindsay Delevingne**, a consultant in McKinsey's New Jersey office; **Anna Gründler**, a consultant in the Hamburg office; **Sean Kane**, a partner in the Southern California office; and **Tim Koller**, a partner in the Stamford office.

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# Earth to CEO: Your company is already at risk from climate change

The next decade is decisive. Acting now to prepare your enterprise for climate change will pay off.

*by Dickon Pinner and Kevin Sneader*

**Does your business** treat climate change as a far-off risk, something for the future but not a priority today?

That's a mistake. Climate change is here. Its economic impact is real and growing, and action now is essential.

Look at Florida's tidal flooding, for example. Waters rose above the "nuisance" threshold in parts of Miami-Dade 14 days a year on average between 2005 and 2017, more than triple the rate of the 11 years prior. Or consider extreme heat like we saw this summer across Europe and are increasingly experiencing globally. In northern India, summer temperatures are hitting 120 degrees Fahrenheit, shutting down outdoor work in cities and entire regions for days at a time. Or agricultural degradation: In some parts of Brazil, the usual two-crop growing season may now only yield a single crop. Around the world, the list goes on and on.

Business leaders can no longer ignore the physical effects of climate change, at least not without peril. Global infrastructure, supply chains, food systems, asset prices, land and labor productivity, and economic growth itself are increasingly at risk of deterioration due to a rapidly changing climate. And a more connected global economy means that risk in one part of the world will often extend well beyond the place of immediate impact.

Navigating the transition the world needs will especially require engagement from renewable and traditional (oil, natural gas, and coal) energy producers. That has to occur at both the company and industry level, given the need for additional

regulation. Getting the balance right between sustaining development and curbing emissions will be particularly complex in emerging economies, where the link between rising growth and rising carbon dioxide is more entrenched than in the developed world. We see this daily in our work, and any climate-change solution has to incorporate this reality.

All businesses—whether involved in energy production or not—can take the following steps right now to be well-prepared for climate change.

First, assess and plan. Doing this right requires conducting a detailed review of all the potential risks to your enterprise from physical climate risk. Use the latest climate modeling and look for systems within or connected to your enterprise that may fail as the world gets steadily hotter and more volatile.

Could your global supply chains become disrupted? Recall, for instance, how extreme flooding in Thailand in 2011 disrupted global production of hard-drive disks, among other products, resulting in a doubling of prices on the global market. When do storm surges and flooding make it challenging to get supplies in and products out of factories on the eastern seaboard of the United States? For hospitals, are your backup generation systems sufficient, and does current regulation allow you to conduct surgery with backup power? For construction, how could high temperatures impair outdoor working hours? For agriculture-based industries, how could drought impact yields?

Second, protect your assets. Armed with this transparency and knowledge, a company can create a set of resiliency and adaptation measures to

# Climate risk assessment and management should be integrated into all key business processes: strategic planning, capital allocation, supply chain management, and product development, to name a few.

reconfigure internal operations and supply chains, redirect capital to growth areas and new business, and protect assets.

For example, owners of infrastructure can incorporate climate risk assessments and adaptation strategies into capital budgets from the start of each project using a resilience scorecard and rating system. Utilities can strengthen their grid, make new investments in energy storage and microgrids, and work with new partners to finance resiliency strategies.

Third, decarbonize your operations. Consumers are demanding climate-friendly products and services and that demand will only grow. A core ingredient for this is to take carbon out of your own operations, something that will soon become table stakes for all companies to be credible with consumers and regulators.

Once they identify the full set of economically viable carbon abatement opportunities across their global footprint, many executives conclude that they need to launch an enterprise-wide

transformation. Such a transformation often requires a centralized organization and ring-fenced capital, with regional teams. It may also be necessary for companies to develop industry-wide transition plans—something we’re seeing across sectors, including plastics, oil and gas, power, agriculture, and mobility. Finally, don’t ignore the emissions that your customers generate from use of your products or services, as these too will come under scrutiny.

Fourth, make climate intelligence a core capability. Climate risk assessment and management should be integrated into all key business processes: strategic planning, capital allocation, supply chain management, and product development, to name a few. Companies that increase the awareness and transparency of their physical climate risk with employees, customers, suppliers, and investors will be more prepared to manage the pervasive and cross-cutting nature of climate risk.

For centuries now, the global economy has taken climate stability for granted. Investing, buying, selling, borrowing, and lending all

require a degree of confidence that tomorrow will be pretty much like today. But climate change is introducing new uncertainty, threatening to upend our assumptions about future growth and prosperity.

The next decade is decisive. Acting now to prepare your enterprise for climate change has a double payoff. Not only will it help you build a lasting commercial advantage, it will also help raise the odds that we avoid potentially catastrophic runaway climate change in the second half of the century.

This commentary first appeared on Fortune.com on September 3, 2019, and is reprinted here by permission.

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# More than values: The value-based sustainability reporting that investors want

Nonfinancial reports helped stimulate the growth of sustainable investing. Now investors are questioning current reporting practices—and calling for changes that executives and board members must understand.

*by Sara Bernow, Jonathan Godsall, Bryce Klempner, and Charlotte Merten*



**As evidence mounts** that the financial performance of companies corresponds to how well they contend with environmental, social, governance (ESG), and other nonfinancial matters, more investors are seeking to determine whether executives are running their businesses with such issues in mind. When companies report on ESG-related activities, they have largely continued to address the diverse interests of their many stakeholders—a long-standing practice that involves compiling extensive sustainability reports and filling out stacks of questionnaires. Despite all that effort, a recent McKinsey survey uncovered something that should concern corporate executives and board members: investors say they cannot readily use companies' sustainability disclosures to inform investment decisions and advice accurately.<sup>1</sup>

What's unusual and challenging about sustainability-focused investment analysis is that companies' sustainability disclosures needn't conform to shared standards in the way their financial disclosures must. Years of effort by standard-setting groups have produced nearly a dozen major reporting frameworks and standards, which businesses have discretion to apply as they see fit (see sidebar "A short glossary of sustainability-reporting terms"). Investors must therefore reconcile corporate sustainability disclosures as best they can before trying to draw comparisons among companies.

Corporate executives and investors alike recognize that sustainability reporting could improve in some respects. One advance that executives and investors strongly support, according to our survey, is reducing the number of standards for sustainability reporting. Many executive respondents said they believe this would aid their efforts to manage sustainability impacts and respond to sustainability-related trends, such as climate change and water scarcity. And many investors said they expect greater standardization of sustainability reports to help them allocate capital and engage companies more effectively.

While these findings might not surprise readers involved with sustainable investing or sustainability reporting, it was striking to learn that investors also support legal mandates requiring companies to issue sustainability reports (Exhibit 1). In this article, we offer executives, directors, and investors a look at how sustainability reporting has evolved, what further changes investors say they want, and how investors can bring about those changes.

## **Reporting today: Externality focused and inconsistent, yet informative**

The current practice of sustainability reporting developed in the 1990s as civil-society groups, governments, and other constituencies called on companies to account for their impact on nature and on the communities where they operate. A milestone was passed in 2000, when the Global Reporting Initiative (GRI) published its first sustainability-reporting guidelines. The following year, the World Business Council for Sustainable Development and the World Resources Institute released the Greenhouse Gas Protocol. The same period also saw the creation of voluntary initiatives, such as the UN Global Compact and the Carbon Disclosure Project (now CDP), encouraging corporations to disclose information on sustainability. Since the financial crisis, additional frameworks and standards have emerged to help companies and their investors develop a greater understanding of the risks and benefits of ESG and nonfinancial factors. For example, the International Integrated Reporting Council (IIRC) advocates integration of financial and nonfinancial reports, the Sustainability Accounting Standards Board (SASB) identifies material sustainability factors across industries, and the Embankment Project for Inclusive Capitalism assembles investors and companies to define a pragmatic set of metrics to measure and demonstrate long-term value to financial markets.

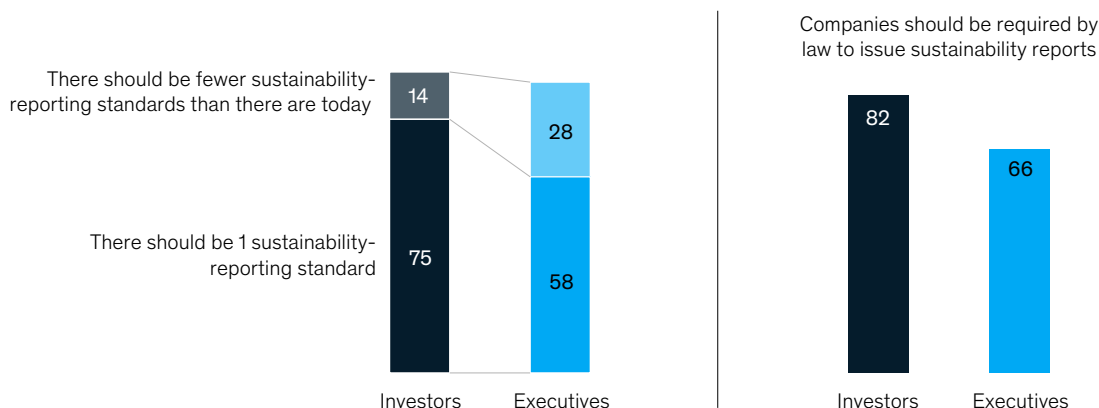
Given the proliferation of reporting frameworks and standards, companies have had to decide for themselves which ones to apply. These frameworks

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<sup>1</sup> For this research, we conducted a survey of 107 executives and investors, representing 50 companies, 27 asset managers, and 30 asset owners. The survey, carried out in January and February of 2019, covered Asia, Europe, and the United States. We also conducted interviews with 26 representatives of asset managers, asset owners, corporations, standard-setting organizations, nonprofit organizations, and academic institutions.

## Investors and executives say that reducing the number of sustainability-reporting standards would be beneficial—and even that there should be legal mandates for reporting.

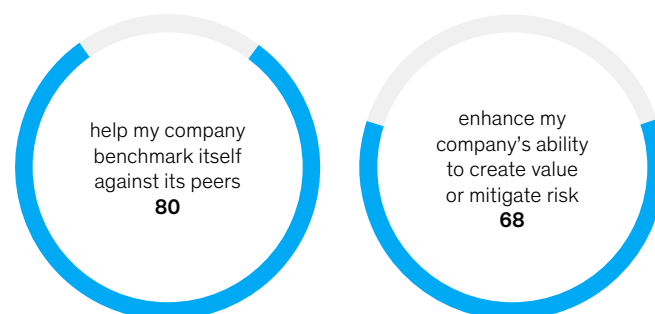
Respondents who agree with statement, %<sup>1</sup>



% of investors who agree or strongly agree that more standardization of sustainability reporting would do the following<sup>1</sup>:



% of executives who agree or strongly agree that more standardization of sustainability reporting would do the following<sup>1</sup>:



<sup>1</sup>Respondents who answered "agree" or "strongly agree." For investors, n = 57; for executives, n = 50.

Source: McKinsey Sustainability Reporting Survey

and standards allow businesses considerable freedom to choose their sustainability disclosures. Many companies select their disclosures by consulting members of stakeholder groups—consumers, local communities, employees, governments, and investors, among others—about which externalities, or impacts, matter most to them and then tallying the stakeholders' interests in some way. More recently, stakeholders have asked for increased disclosure about how companies address opportunities and risks related to sustainability trends, such as climate change and water scarcity, which can meaningfully affect a company's assets, operations, and reputation.

The scope and depth of these disclosures differ considerably as a result of the subjective choices companies make about their approaches to sustainability reporting: which frameworks and standards to follow, which stakeholders to address, and which information to make public. According to the executives and investors we surveyed, the diversity of these disclosures is a defining feature of sustainability reporting as we know it—and a source of difficulty, as we explain in the following section of this article.

Nevertheless, 30-odd years of sustainability reporting have produced a trove of useful data.

## A short glossary of sustainability-reporting terms

In this article, we use the following terms for certain elements of sustainability reporting:

— **Sustainability disclosure.** This disclosure is an item of qualitative or quantitative information about a company's performance on a topic not addressed by standard financial and operational disclosures. Sustainability disclosures ordinarily relate to environmental, social, and governance matters, including companies' sustainability impacts and responses to external sustainability trends. These disclosures sometimes encompass other topics, too, such as HR and intellectual property.

— **Sustainability report.** This report is a document containing a set of sustainability disclosures from an organization for a period of time. It

can be a stand-alone document or a component of the annual report.

— **Sustainability-reporting requirement.** This requirement is a mandate from an authority (such as a regulator, a stock exchange, or a civil-society group) about a sustainability report's content and nature. Some requirements apply to all companies in a given jurisdiction—for example, Directive 2014/95/EU of the European Parliament and the European Council, requiring some large companies to issue nonfinancial disclosures. Others, such as the UN Global Compact, apply only to companies that have voluntarily pledged to abide by them.

— **Sustainability-reporting framework.** This framework is a set of guidelines for determining what topics and

disclosures a sustainability report should cover. The International Integrated Reporting Framework, published by the International Integrated Reporting Council (IIRC), is one example.

— **Sustainability-reporting standard.** This standard is a set of specifications for measuring and disseminating sustainability disclosures. Examples include the Global Reporting Initiative's GRI Standards and the 77 industry-specific standards published by the Sustainability Accounting Standards Board.

Stakeholders can use this information to track the relative sustainability performance of companies from year to year. By aggregating data from many companies, stakeholders can not only discern patterns and trends in companies' responses to sustainability issues but compare and rank businesses as well.

Analysts in academia, government, and the private sector have also used these sustainability disclosures to examine the link between sustainability performance and financial performance. A substantial body of research shows that companies that manage sustainability issues well achieve superior financial results.<sup>2</sup> (Researchers have shown only that these two phenomena are correlated, not

that effective sustainability management leads to better financial outcomes.)

Investors and asset owners appear to be taking note of corporate sustainability disclosures and adapting their investment strategies accordingly. The Global Sustainable Investment Alliance has found that the quantity of global assets managed according to sustainable-investment strategies more than doubled from 2012 to 2018, rising from \$13.3 trillion to \$30.7 trillion.<sup>3</sup> BlackRock reports that assets in sustainable mutual funds and exchange-traded funds in Europe and the United States increased by more than 67 percent from 2013 to 2019 and now amount to \$760 billion.<sup>4</sup> And research by Morgan Stanley indicates that a majority of large asset

<sup>2</sup> Alexander Bassen, Timo Busch, and Gunnar Friede, "ESG and financial performance: Aggregated evidence from more than 2000 empirical studies," *Journal of Sustainable Finance & Investment*, 2015, Volume 5, Issue 4, p. 210–33; Robert G. Eccles, Ioannis Ioannou, and George Serafeim, "The impact of corporate sustainability on organizational processes and performance," *Management Science*, 2014, Volume 60, Issue 11, pp. 2835–57; Gordon L. Clark, Andreas Feiner, and Michael Viehs, *From the stockholder to the stakeholder: How sustainability can drive financial outperformance*, a joint report from Arabesque and University of Oxford, March 2015, insights.arabesque.com; "Sustainability: The future of investing," BlackRock, February 1, 2019, blackrock.com.

<sup>3</sup> *Global Sustainable Investment Review 2012* and *Global Sustainable Investment Review 2018*, Global Sustainable Investment Alliance, gsi-alliance.org.

<sup>4</sup> "Sustainability: The future of investing," BlackRock, February 1, 2019, blackrock.com.

# Investors want companies to provide more sustainability disclosures that are material to financial performance.

owners are integrating sustainability factors into their investment processes. Many of those asset owners started to do so only during the four years before the survey.<sup>5</sup>

## What investors want: Financial materiality, consistency, and reliability

With so much capital at stake, investors have begun to question prevailing sustainability-reporting practices. The shortcomings investors now highlight have existed for some time but were mostly acceptable to early sustainable investors and the diverse civil-society stakeholders that used to be the primary readers of sustainability reports. But now that more asset owners and asset managers are making investment and engagement decisions with sustainability in mind, a louder call has gone out for sustainability disclosures that meet the following three criteria.

### Financial materiality

Investors acknowledge that their expectations for sustainability disclosures have shifted. As the head of responsible investing at a large global pension fund remarked, “The early days of sustainable investing were values based: How can our investing live up to our values? Now, it is *value*-based: How does sustainability add value to our investments?”

From our interviews and survey results, it is apparent that investors want companies to provide more sustainability disclosures that are material to financial performance. According to a senior sustainable-investing officer at one top 20 asset manager, “Corporations do not provide systematic data on one-third of the sustainability factors

[that we consider] material.” This could change as more companies issue reports in line with the sector-specific standards that SASB created in consultation with industry experts and investors.

Government authorities and civil-society organizations also appear to be coming around to investors' views about the material connection between a company's handling of sustainability factors and its financial performance. The European Union's 2014 directive on nonfinancial reporting and the Financial Stability Board's creation of the Task Force on Climate-related Financial Disclosures in 2015 are two signals that financial regulators realize sustainability-related activities can materially affect the financial standing of companies and should be reported accordingly.

### Consistency

With so many reporting frameworks and guidelines to choose from, and so many potential stakeholder interests to address, companies rarely make sustainability disclosures that can be compared as neatly as their financial disclosures can. This circumstance makes the job of investors more difficult, as they indicated in response to our survey (Exhibit 2). As the head of sustainable investing at a major asset manager explained, “We have positions in over 4,500 companies. Unless [sustainability information] is comparable, hard data, it is of little use to us.”

Inconsistencies among sustainability disclosures, which arise through no fault of the companies producing them, can also create problems for the many investors that obtain sustainability data from third-party services rather than individual

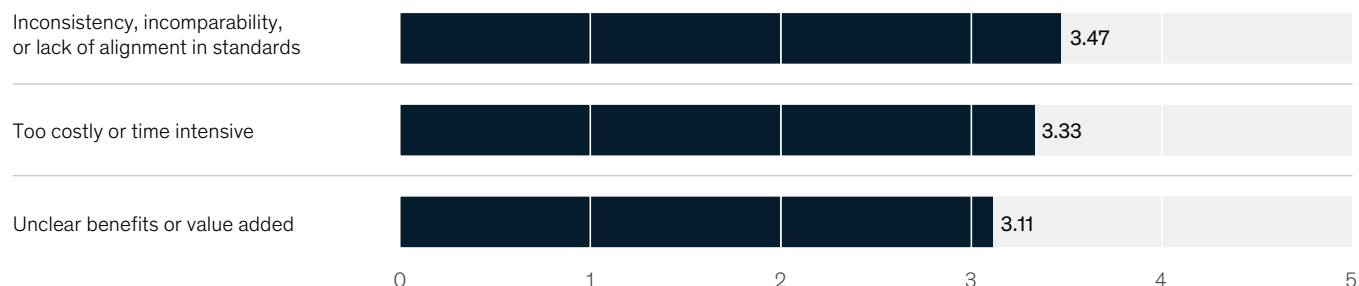
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<sup>5</sup> “Sustainable signals: Asset owners embrace sustainability,” Morgan Stanley, June 18, 2018, [morganstanley.com](https://www.morganstanley.com).

Exhibit 2

## Investors report that the main shortcomings of current sustainability-reporting practices are inconsistency, incomparability, and lack of alignment in standards.

**Top challenges associated with current sustainability-reporting practices,**<sup>1</sup> mean rating on 1–5 scale, where 5 is most challenging



<sup>1</sup>n = 57.

Source: McKinsey Sustainability Reporting Survey

sustainability reports. These services use different methods to estimate missing information, so there are discrepancies among data sets. Some services normalize sustainability information, replacing actual performance data (such as measurements of greenhouse-gas emissions) with performance scores calculated by methods the services don't reveal. Research shows a low level of correlation among the data providers' ratings of performance on the same sustainability factor.<sup>6</sup>

Similarly, proprietary indexes and rankings of sustainable companies, which some asset managers use to construct index-fund portfolios, can also diverge greatly. It is not unusual for a company to be rated a top sustainability performer by one index and a poor performer by another.<sup>7</sup> And some data services fail to include sustainability data companies have disclosed.<sup>8</sup>

### Reliability

As the head of responsible investing for one of the world's five largest pension funds put it, "Many companies do not have the systems in place to collect quality data for [sustainability] reporting."

For certain tangible sustainability factors, such as greenhouse-gas emissions, performance-measurement systems are generally well established. For other factors, such as corporate culture, human capital, and diversity and inclusion, clear ways to gauge performance are more elusive.

Investors also harbor doubts about corporate sustainability disclosures because few of them undergo third-party audits. Nearly all the investors we surveyed—97 percent—said that sustainability disclosures should be audited in some way, and 67 percent said that sustainability audits should be as rigorous as financial audits (Exhibit 3).

### Refining the practice of sustainability reporting

In our survey and interviews, one priority for improving sustainability reporting stood out: ironing out the differences among reporting frameworks and standards. When we asked survey respondents to assess the challenges of sustainability reporting, executives and investors both rated "inconsistency, incomparability, or lack of alignment in standards"

<sup>6</sup> Gregor Dorfleitner, Gerhard Halbritter, and Mai Nguyen, "Measuring the level and risk of corporate responsibility—an empirical comparison of different ESG rating approaches," *Journal of Asset Management*, 2015, Volume 16, Issue 7, pp. 450–66. The correlation between ratings of the same performance factor is typically less than 0.6 and can fall to as low as 0.05. By comparison, credit ratings are highly correlated (0.9).

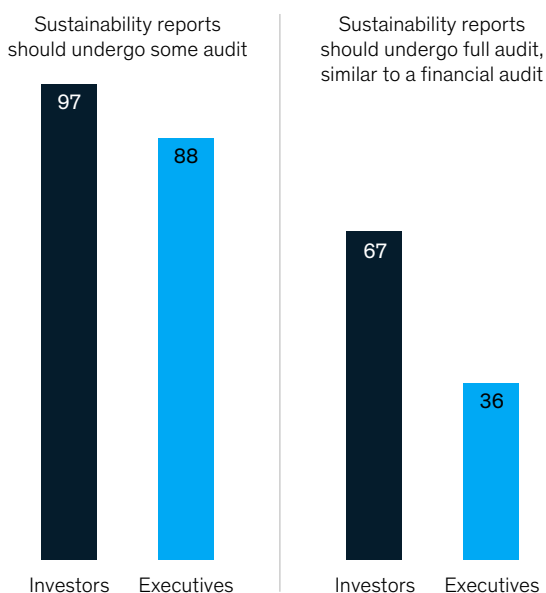
<sup>7</sup> James Mackintosh, "Is Tesla or Exxon more sustainable? It depends whom you ask," *Wall Street Journal*, September 17, 2018, wsj.com.

<sup>8</sup> "Sustainability: The future of investing," BlackRock, February 1, 2019, blackrock.com.

Exhibit 3

## More investors believe that sustainability reports should be audited and that the audits should be full audits, similar to financial ones.

Respondents who agree with statement, %<sup>1</sup>



<sup>1</sup> Respondents who answered "agree" or "strongly agree." For investors, n = 57; for executives, n = 50.

Source: McKinsey Sustainability Reporting Survey

as the most significant challenge. A majority of respondents to our survey—67 percent—said there should be only one standard, and an additional 21 percent said there should be fewer than exist now.

The investors and executives who participated in our research also described several benefits of making reporting frameworks and standards more uniform. Investors expect greater uniformity to help companies disclose more consistent, financially material data, thereby enabling investors to save time on research and analysis and to arrive at better investment decisions. Some efficiency gains would accrue as third-party data providers begin aggregating sustainability information as consistent as the information they get from corporate financial statements.

Most of the investors we surveyed—63 percent—also said they believe that greater standardization

will attract more capital to sustainable-investment strategies. However, about one-fifth of the surveyed investors said that uniform reporting standards would level the playing field, diminishing their opportunities to develop proprietary research insights or investment products (Exhibit 4).

Executives made clear, in our conversations, that they devote excessive effort and expense to answering numerous specialized requests for what is essentially the same information, such as greenhouse-gas emissions data that must be tabulated in different ways to conform to different standards.

This kind of burden would be lessened if the providers of reporting frameworks and standards combined or rationalized their rules and thereby reduced the number of major frameworks and standards to one or two. Companies could then use the same disclosures to fulfill the reporting demands of multiple authorities. (They could still develop additional sustainability disclosures if they chose to address stakeholder queries or concerns that the main mechanism didn't cover.) Establishing one or two reporting standards would also simplify the task of auditing sustainability disclosures, making it more economical for companies to have their reports independently verified.

## How investors can help effect change

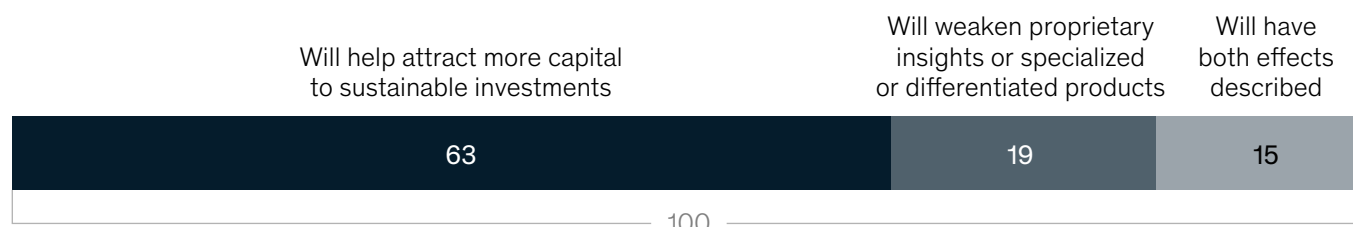
Reducing the number of reporting frameworks and standards will probably involve several more years of effort by businesses, investors, and standard-setting organizations—which have begun to identify gaps and redundancies among disclosures—and by other stakeholders, such as civil-society groups and regulators. As it is, many investors avoid participating in standard-setting efforts. Some we interviewed said they distance themselves because they feel that standard setting should address their needs as a matter of course. Yet some standard setters told us they assume that investors can readily obtain the sustainability information they value and therefore focus on the interests of other stakeholders.

Our conversations lead us to believe that there's some truth to both viewpoints. Yet our survey findings

## Exhibit 4

### Many investors believe that harmonized sustainability-reporting standards will attract more capital to sustainable investors, though some express concern about losing an edge.

Investors who agree with statement about effect of harmonized standards, % of respondents<sup>1</sup>



Note: Figures may not sum to 100%, because of rounding.

<sup>1</sup> Respondents who answered "agree" or "strongly agree"; n = 57.

Source: McKinsey Sustainability Reporting Survey

and interviews also suggest that investors could make valuable contributions to standard-setting efforts if they chose to increase their participation. Active investors are likelier to do so, since they pay more attention than index investors to the sustainability disclosures of individual companies. Until investors clarify which sustainability disclosures they want and help to rationalize frameworks and standards, sustainability reports might continue to deliver less material information than they would like.

Investors can do several other things to make better use of the sustainability-related information companies now make available. First, they can articulate the sustainability disclosures that matter most for their investment decisions and convey these interests to businesses. Going a step further, more investors could engage companies (through direct dialogue and shareholder voting) about their approach to managing sustainability issues.

More investors could also adopt the still-uncommon practice of collecting and analyzing data from sources other than corporate sustainability reports

and disclosures. Some investors have developed algorithms that automatically gather nonfinancial data from public sources (such as government databases of health and safety incidents or websites where people post comments about their employers) and scan these data for patterns that relate meaningfully to corporate financial performance.

As the market for sustainable investments expands, more investors are taking a keen interest in sustainability reports from companies. Yet the information these investors find seldom meets their expectations. From an investor's standpoint, sustainability disclosures tend to be loosely related to financial performance, difficult to compare from one company to another, and less than reliable. Investors who take part in efforts to improve sustainability-reporting practices could gain an edge over their more detached peers. Executives and board members should stay attuned to these efforts, and even participate in them, to maintain their companies' standing with shareholders.

**Sara Bernow** is a partner in McKinsey's Stockholm office, where **Charlotte Merten** is a consultant; **Jonathan Godsall** is a partner in the New York office; **Bryce Klempner** is a partner in the Boston office.

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70

Mapping the benefits of a  
circular economy

76

Toward a circular economy  
in food

# Getting circular





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# Mapping the benefits of a circular economy

Companies in many industries can improve their financial performance by reconfiguring product life cycles and reusing natural capital.

Is there a reliable way for industries to increase their profitability while reducing their dependence on natural resources? In recent years, McKinsey research has shown that the circular economy—using and reusing natural capital as efficiently as possible and finding value throughout the life cycles of finished products—is at least part of the answer.<sup>1</sup> In 2015, as part of a major study with the Ellen MacArthur Foundation, we demonstrated that such an approach could boost Europe’s resource productivity by 3 percent by 2030, generating cost savings of €600 billion a year and €1.8 trillion more in other economic benefits.

Exhibit 1 shows that most of the 28 industries we studied could adopt three to four of six potential circular-economy activities, improving performance and reducing costs accordingly. These are shifting to renewable energy and materials (Regenerate), promoting the sharing of products or otherwise prolonging product life spans through maintenance and design (Share), improving product efficiency and removing waste from supply chains (Optimize),

keeping components and materials in “closed loops” through remanufacturing and recycling (Loop), delivering goods and services virtually (Virtualize), and replacing old materials with advanced renewable ones or applying new technologies such as 3-D printing (Exchange). Most industries already have profitable opportunities in each area.

On the next pages we explore how leaders are putting these principles to work in three short case studies covering emerging markets and specific industries.

*For additional research on the circular economy, see “Finding growth within: A new framework for Europe,” in The circular economy: Moving from theory to practice, McKinsey Center for Business and Environment, October 2016, on McKinsey.com, by **Morten Rossé**, an associate partner in McKinsey’s Munich office, **Martin Stuchtey**, an alumnus and former director of the McKinsey Center for Business and Environment, and **Helga Vanthournout**, a senior expert in the Geneva office.*

<sup>1</sup> See, for example, Hanh Nguyen, Martin Stuchtey, and Markus Zils, “Remaking the industrial economy,” *McKinsey Quarterly*, February 2014, McKinsey.com; and Scott Nyquist, Matt Rogers, and Jonathan Woetzel, “The future is now: How to win the resource revolution,” *McKinsey Quarterly*, October 2016, McKinsey.com.

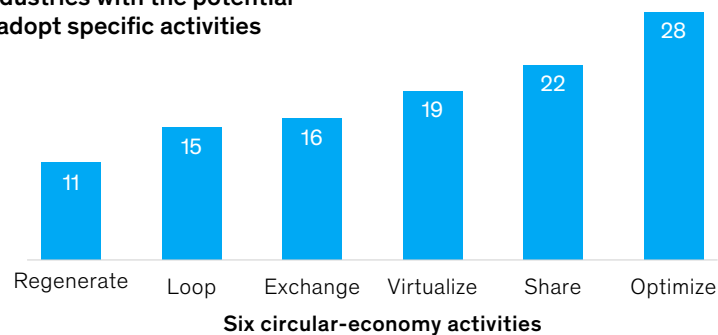
Exhibit 1

## Six circular-economy activities have the potential to improve performance and reduce costs for a number of industries.

Out of 28 industries studied...



### Number of industries with the potential to profitably adopt specific activities



Source: *Growth within: A circular economy vision for a competitive Europe*, Ellen MacArthur Foundation and the McKinsey Center for Business and Environment, June 2015

## Building a business from waste

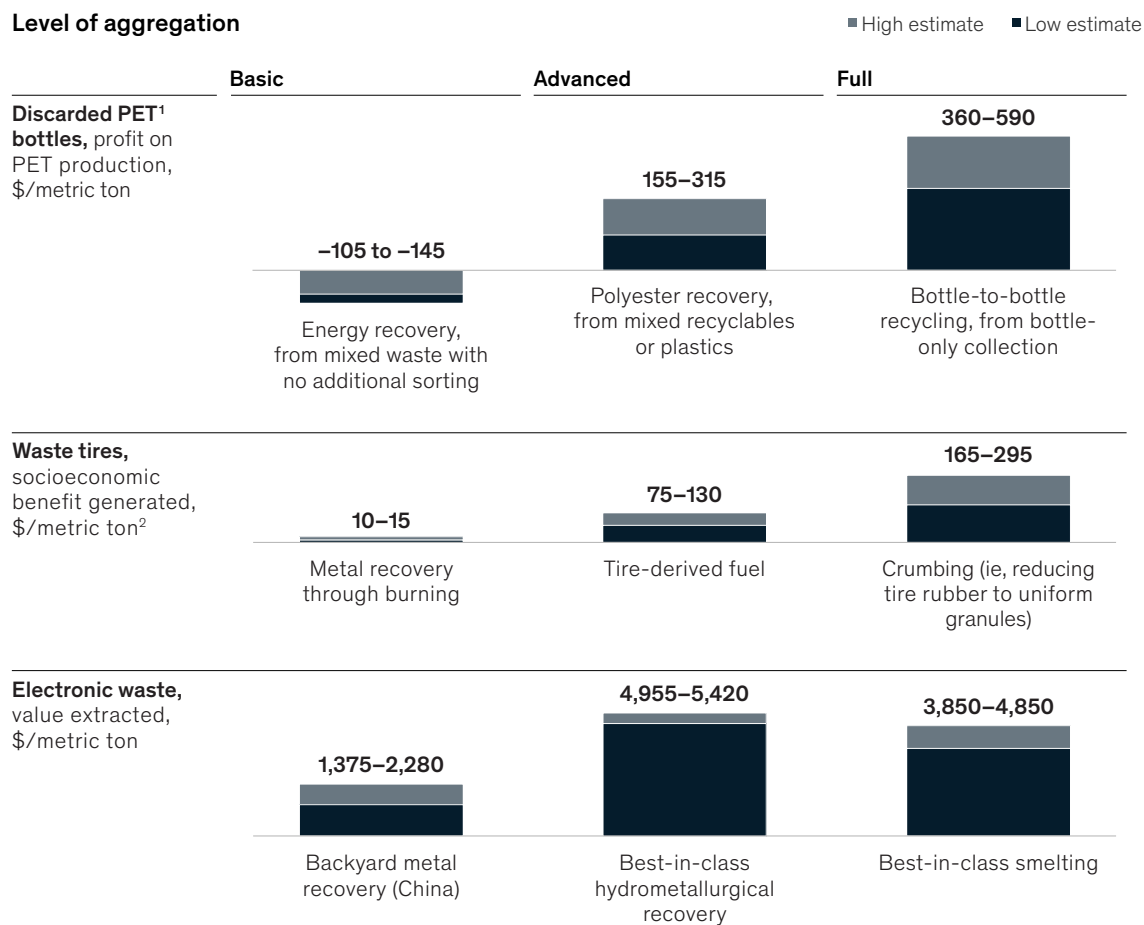
Economic growth in emerging markets has helped to raise living standards—but inevitably it has also generated massive consumer and industrial waste. Many municipalities in these markets spend up to half their budgets on solid-waste management. Innovative businesses, however, drawing on circular-economy principles, are finding ways to convert trash into income streams. By aggregating volumes substantial enough to justify business investment, they are able to create the infrastructure to organize and manage waste supply chains.

Exhibit 2 shows three opportunities and three levels of value for each. Polyethylene terephthalate bottles in mixed waste, for example, can be incinerated, but the economic payoff from the energy generated is low. Recovering the bottles' material value, from mixed recyclables or bottle-to-bottle recycling, produces a much higher payout. Metals, meanwhile, are commonly extracted from tires in open backyard fires—at great cost to human health and the environment. Aggregating tires for use as industrial fuel, on the other hand, could increase their value almost tenfold, while

Exhibit 2

## Aggregating flows and providing necessary scale can yield high-performing value recovery.

### Level of aggregation



<sup>1</sup>Polyethylene terephthalate.

<sup>2</sup>South Africa example; socioeconomic benefit includes operating profit, wages, interest and rent, taxes, R&D investment, social uplift and education spending, and is net of public investment (fees levied). Exchange rate: \$1 = 10 South African rand (average 2013–15). Source: *Plastics News*; Umicore; United Nations University/Step Initiative; WRAP



crumbling them to make road-paving material yields even more. The same principle works for electronic waste: shifting from small-scale recycling to best smelting processes or liquid-chemical extraction techniques multiplies yields. Bear in mind that pound for pound, there is more gold in electronic scrap than there is in ore.

Scaling up requires management discipline. Successful programs such as the tire-recycling exchange of the Recycling and Economic Development Initiative of South Africa (REDISA) have a strong balance sheet that encourages investment by downstream waste users and the management expertise to hone operations and attract talent. They also invest in infrastructure, including IT. REDISA's digitized product tagging improves recovery, which in turn allows manufacturers to design tires with less toxic materials.

*For the full article, see "Ahead of the curve: Innovative models for waste management in emerging markets," in The circular economy: Moving from theory to practice, McKinsey Center for Business and Environment, October 2016,*

*on McKinsey.com, by Hauke Engel, a consultant in the Frankfurt office, Martin Stuchtey, and Helga Vanthournout.*

## Making 'fast fashion' sustainable

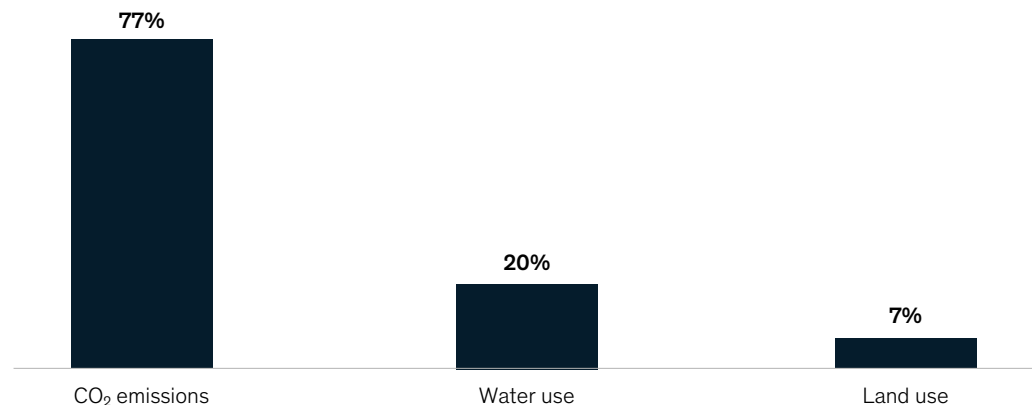
Apparel sales have risen sharply in recent years, as businesses have used "fast fashion" design and production systems to cut prices and introduce new lines more often. From 2000 to 2014, global clothing production doubled and the number of garments sold per person increased by 60 percent. In five large developing countries—Brazil, China, India, Mexico, and Russia—sales grew eight times faster than in large advanced countries, though the average advanced-country resident still buys more clothing each year.

Narrowing that gap represents a big opportunity for clothing companies, but the environmental consequences are clear (Exhibit 3). Making and laundering clothes typically requires large quantities of water and chemicals; fiber farms occupy vast tracts of land; greenhouse-gas emissions are significant. After consumers discard old garments—

Exhibit 3

**As consumer spending increases, especially in emerging economies, the clothing industry's environmental impact could expand greatly.**

**Increase in clothing industry's environmental impact from 2015 to 2025<sup>1</sup>**



<sup>1</sup>Estimated, assumes 80% of emerging markets achieve Western per capita consumption levels while rest of the world's current level remains constant. CO<sub>2</sub> emissions were measured in millions of metric tons; water use, billions of cubic meters; and land use, millions of hectares. Source: WorldBank; McKinsey analysis



something that happens ever more quickly—current technologies cannot reliably turn them into fibers for new clothes. Without improvements in how clothing is made, cared for, and disposed of, apparel's environmental impact will worsen.

Clothing businesses are taking note. Some have formed coalitions to promote nontoxic chemicals, improve cotton farming, and raise production standards. Others are helping develop standards for garments that can be more easily reused or recycled, and investing in the development of new fibers that will lower the environmental effects of production. Using more sustainable methods may cost slightly more, but doing so can also spur innovation, guard against supply-chain shocks such as drought conditions that affect cotton supplies, and enhance corporate reputations.

*For the full article, see "Style that's sustainable: A new fast-fashion formula," October 2016, on McKinsey.com, by **Nathalie Remy**, a partner in the Paris office, **Eveline Speelman**, a consultant in the Amsterdam office, and **Steven Swartz**, a partner in the Southern California office.*

## Why supply chains hold the key

The global consumer sector is expected to grow 5 percent a year for the next two decades. But environmental and social problems pose a real threat. We estimate that more than half of the enterprise value of the top 50 consumer companies depends on their projected growth, which is vulnerable to issues such as drought, government limits on greenhouse-gas emissions, and reputational damage from insufficient attention to pollution and safety.

When managing their sustainability performance, consumer companies often start with their

own operations. The largest opportunities for improvement, however, can probably be found in supply chains, which typically account for 80 percent of a consumer business's greenhouse-gas emissions and more than 90 percent of its impact on air, land, water, and biodiversity (Exhibit 4).

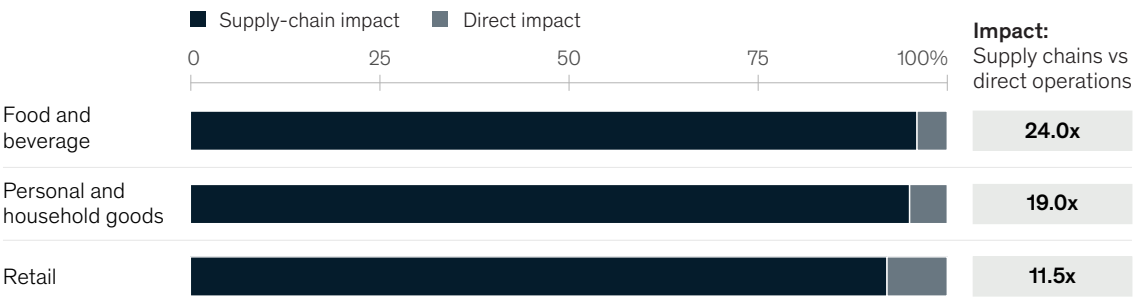
Identifying sustainability challenges along the entire supply chain, then, is crucial. However, fewer than 20 percent of the 1,700 respondents to a survey by the Sustainability Consortium are doing this. Best-practice companies assist suppliers with managing sustainability impact, offering incentives for improved performance, sharing technologies that can help optimize the use of resources such as water and soil, and closely monitoring performance to be able to intervene quickly when problems arise.

*For the full article, see "Starting at the source: Sustainability in supply chains," November 2016, on McKinsey.com, by **Anne-Titia Bové**, a specialist in the São Paulo office, and **Steven Swartz**.*

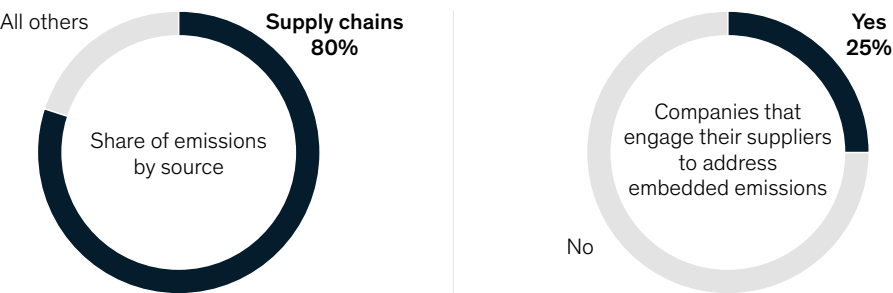
Exhibit 4

Most of the environmental impact associated with the consumer sector is embedded in supply chains.

Impact by source on natural capital resources, (eg, air, soil, or water) for selected industries



Greenhouse-gas emissions for 4 industries selected



Note: Supply chains are defined here as all organizations, including energy providers involved in producing and distributing consumer goods. Greenhouse-gas-emissions data are for electronics and electrical equipment, food, manufacturing, and textile, apparel, and shoes. Source: Carnegie Mellon University; CDP (formerly the Carbon Disclosure Project); GreenBiz; McKinsey analysis



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# Toward a circular economy in food

The French food and water company Danone has a history of environmental awareness. In this interview with McKinsey partner Clarisse Magnin, CEO Emmanuel Faber discusses his commitment to resource efficiency.

**McKinsey Quarterly:** *What inspired Danone's current thinking?*

**Emmanuel Faber:** Three things. My own upbringing and convictions, the culture and history of Danone, and the overwhelming case for change.

I grew up in the Alps, where the beauty of the natural cycles seeded in me the underlying importance of something that we as managers can often lose sight of—namely, that life is more than ideas, mathematical models, and software. I later spent three years in Asia, including Indonesia and China, where I saw firsthand how fast resources were being depleted in emerging markets.

Danone's commitment to tackling these problems is not new, so it was always fitting that I should join such a company. More than 40 years ago, in Marseille, Antoine Riboud, our founding CEO, made a speech in which he pointed out that we only have one Earth, that it's our responsibility to look after it, and that as a business we would pursue a dual economic and social agenda.

Last, the world is changing. Cheap, low-quality calories have dominated the industrial-food business for nearly 100 years, but we are reaching the end of this era. Consumer tastes and behavior are evolving, and as part of this evolution consumers expect us to act differently.

**McKinsey Quarterly:** *Can you say more about these changes?*

**Emmanuel Faber:** Supply chains are increasingly global, which means there are systemic risks that we don't see. While we've been able to improve food security in many regions, this has also led to other issues, such as declining soil fertility and threats to the biodiversity of our planet. At the same time, we cannot continue to reduce the costs of agricultural production. The volatility of input prices is much

greater than it used to be, and food inflation is rising. The price of milk, our major raw material, was near an all-time low in 2009 but has gone up three times since and 18 months ago almost hit an all-time high.

On top of that, we need to address the needs of a growing population, new regulatory requirements in the area of public health, and the increasing impact of diseases such as obesity and diabetes. Some companies are turning to big data management and ERP<sup>1</sup> to meet these challenges. But I believe this is the wrong approach. We need a comprehensive response to tackle growing resource scarcity, which both drives the efficient use of those resources through the supply chain and brings healthy food to as many people as possible. Danone's approach rests on what we call consumption ecosystems, taking into account every stage in the life of products, from the production of raw material to the "second life" of packaging.

**McKinsey Quarterly:** *What does that mean in practice for the way you make products and source materials?*

**Emmanuel Faber:** To embed the principles of the circular economy in our operations, we have started managing our three key resources—water, milk, and plastic—as cycles rather than as conventional linear supply chains.

One example of this is what we are doing in yogurt. To make Greek yogurt, you use a "strained" technology with a membrane, extracting a lot of acid whey. Instead of just seeing this acid whey as an effluent, we are testing technology solutions in five or six countries and working with different partners to find ways to use whey as a resource. We are already using whey protein, for instance, in our Early Life Nutrition business, and we will soon be able to use it for animal feed, fertilizers, and energy. What we're doing is turning something that is a challenge today into something that will have value tomorrow.

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<sup>1</sup> Enterprise resource planning.





## Emmanuel Faber

### Education

Graduated with bachelor's degree in business administration from HEC Paris

### Career highlights

Danone Group  
(1997–present)

CEO (2014–present)

Vice chairman, board of directors (2011–present)

Deputy general manager (2008–14)

Vice president, Asia–Pacific region (2005–08)

Head of finance, strategies, and information systems (1997–2005)

Legris Industries  
(1993–97)

Chief executive officer (1996–97)

Chief administrative and financial officer (1993–96)

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Under a new partnership with Veolia, a global waste-management company, we are working together on building a circular economy around water and packaging waste, testing new ideas and investigating new technology. One project, for example, aims to optimize recycling techniques so we can build plants with zero liquid discharge.

**McKinsey Quarterly:** *What are you doing with plastic waste?*

**Emmanuel Faber:** At the moment, nearly 30 percent of our total packaging comes from recycled materials, and as much as 80 percent in the case of cartons, but we continue to make progress. For plastics, the endgame could be the creation of a net-positive cycle in partnership with other large companies, which would mean recycling more plastics than we put on the market in the first place.

Plastics are interesting because they highlight an important challenge of a circular economy, namely managing the “hierarchy of degradation.” If, say, we allow virgin PET<sup>2</sup> to go into landfills, its reusability potential ends up being low. But if we save it in a closed-loop system, it will continue to be of food-grade quality, good enough to reuse in food packaging. This means it stays at a high level in the hierarchy of degradation. Our ambition is to create a second life for all the plastic packaging we put on the market, so that we move toward 100 percent recycling in this respect. Part of the plan is also to launch a 100 percent biosourced second-generation plastic.

**McKinsey Quarterly:** *What changes have you made to Danone's organization to reflect the new ways of working?*

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<sup>2</sup> Polyethylene terephthalate.

**Emmanuel Faber:** We have created a position in the executive committee in charge of our Strategic Resources Cycles unit. This person oversees separate internal units for the milk cycle, the water cycle, and the plastic cycle. This organizational change has already started to transform the way we work, because it is cross-divisional and cross-functional.

We have also created a Milk Technology Center that reports to the Milk Cycle Organization—part of the Strategic Resources Cycles unit—not to R&D or to the dairy business, as it might under a conventional structure. The aim here is to achieve a step change in our ability to maximize the value of milk and limit the waste from milk production.

**McKinsey Quarterly:** *How do you change Danone's culture to embrace circular-economy thinking?*

**Emmanuel Faber:** Danone has circular-economy principles in its DNA, and people join Danone because of its unique culture and heritage. We do, however, need to continue to create the conditions for new generations to embrace our founding principles of business success and social progress.

The time horizon is critical. You won't start anything if you only think of the next three months; it's got to be something for the next 30 years. At the same time, you need breakthrough objectives. We would never have made as much progress with our CO<sub>2</sub> reduction program in 2008 if we had just gone for a 2 percent reduction per year rather than 30 percent over five years, which we set ourselves. We actually achieved 42 percent.

If you know at the outset how you are going to achieve an objective, you're not aiming high enough to get the organization to start working differently. You have to come up with an objective which is aspirational—something that is too far away to know

how it will be reached. That was our intent when we announced, in December last year, that we would target zero net carbon emissions on our full scope of responsibility by 2050.

You also need an investment-payback period that is longer than it is in today's traditional model—five years instead of three; seven years instead of five. For our CO<sub>2</sub> reduction program, we created a special green CapEx category with this in mind. Some bets may have no payback at all. It's about getting a balance between the short, the medium, and the long term.

Incentives are also an important part of the culture because they really show that the leadership team means what it says. A few years ago, the annual incentive program for the 1,500 top managers at Danone encompassed the CO<sub>2</sub> reduction objective, to the point where, broadly speaking, the yearly bonus attached to CO<sub>2</sub> reduction was equivalent to the yearly bonus attached to profit generation. This is just one example of how we're using incentives to embed our vision across the business.

On top of this, and in order to foster change with Danone's 100,000 employees, the company launched a manifesto to underpin the way we intend to deliver on our mission. This manifesto aims at deepening and enriching Danone's mission, to bring it to the next level of impact, through a series of initiatives across the company and outside it. For instance, a dedicated internal website has been created where people can post ideas and thoughts related to the manifesto and contribute to Danone's journey. To support and coordinate the establishment of the manifesto across Danone's teams and local communities worldwide, the role of chief manifesto catalyst has been created to maximize the potential of this process and catalyze bottom-up innovation.



**McKinsey Quarterly:** *How do you think this approach will ultimately benefit Danone, as well as society and the environment?*

**Emmanuel Faber:** Consumers are interested in what is at work in the products they eat, how these products were produced and delivered, and what is

their effect on the body. I believe there is a ladder of brand equity in food. There is a lot attached to the values and culture. Ultimately, the brand should be the link with the consumer and tell the story.

This interview was conducted by **Clarisse Magnin**, a principal in McKinsey's Paris office.

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# Articles by Dickon Pinner

**82**

Reduced dividends on  
natural capital?

**90**

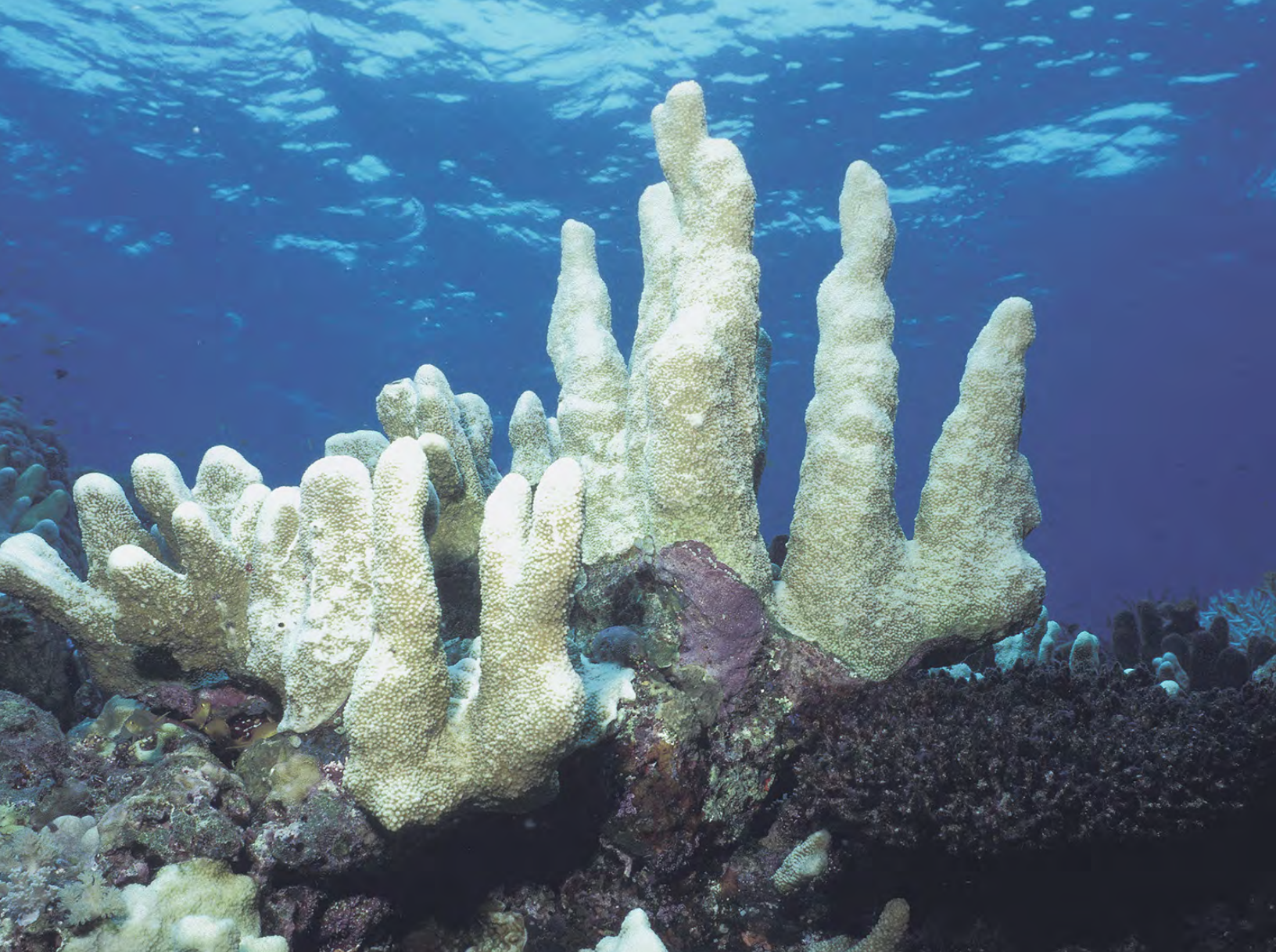
Reimagining mobility: A  
CEO's guide

**100**

How solar energy can  
(finally) create value

**106**

Brave new world:  
Myths and realities of  
clean technologies



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# Reduced dividends on natural capital?

The world's stock of natural resources performs a range of services that are essential to human well-being. But climate change is accelerating the depletion of natural capital.

*by Jonathan Woetzel, Dickon Pinner, Hamid Samandari, Hauke Engel, Mekala Krishnan, Claudia Kampel, and Johanna von der Leyen*

**Natural capital** provides the world's population with a variety of critical services. These include ecosystem services (providing goods such as food, fiber, fuel, water, and wood), regulating environmental conditions (by controlling pollution, protecting against natural hazards like floods and forest fires, and purifying water, among others), and supporting recreation, spiritual fulfillment, aesthetic enjoyment, and other cultural practices.

But climate change accelerates the depletion of natural capital and ecosystem services as it alters major geophysical conditions—average surface temperatures, ocean body temperatures, precipitation patterns, the oxygen content and acidity of seawater—too quickly for natural systems to adapt. When these changes reach thresholds that ecosystems can no longer sustain, natural capital and ecosystem services often degrade along a nonlinear path.<sup>1</sup>

It is particularly hard to manage natural capital losses. The time between human actions that affect natural capital and the environmental and ecological responses to those actions can be long. Problems that occur within ecosystems can be hard to diagnose and understand because the systems are so complex. And traditional economic measures discount natural capital by recording only positive

outcomes from the depletion of natural capital (for example, the GDP contributions of the fishing industry), and none of the negative outcomes (such as the impact on marine species).

These trends are having significant effects on three major types of natural capital that we examine in this case study: glaciers, oceans, and forests. Determining the potential socioeconomic impact from natural capital destruction is challenging due to the manifold and complex ways that societies depend on the natural world.

As result, in this study, we highlight the enormous dependency many communities have on natural capital, for example on the water people drink or on fishing and tourism to provide livelihoods, identify the pace of natural capital destruction in parts of the world such as the Himalayas, and how that might continue in the next few decades (see sidebar, “An overview of the case study analysis”). We also explore possibilities for combating natural capital destruction.

### **Glaciers are melting, and the change has begun to disrupt crucial supplies of freshwater**

Glaciers play an essential part in regulating the supply of freshwater. More than one-sixth of the

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<sup>1</sup> Virginia R. Burkett et al, “Nonlinear dynamics in ecosystem response to climatic change: Case studies and policy implications,” *Ecological Complexity*, December 2005, Volume 2, Number 4.

**The time between human actions that affect natural capital and the environmental and ecological responses to those actions can be long.**



## An overview of the case study analysis

**In *Climate risk and response: Physical hazards and socioeconomic impacts*,<sup>1</sup>** we measured the impact of climate change by the extent to which it could affect human beings, human-made physical assets, and the natural world. We explored risks today and over the next three decades and examined specific cases to understand the mechanisms through which climate change leads to increased socioeconomic risk.

In order to link physical climate risk to socioeconomic impact, we investigated cases that illustrated exposure to climate change extremes and proximity to physical thresholds. These cover a range of sectors and geographies and provide the basis of a “micro-to-macro” approach that is a characteristic of McKinsey Global Institute research. To inform our selection of cases, we considered over 30 potential combinations of climate hazards, sectors, and geographies based on a review of the literature and expert interviews on the potential direct impacts of physical climate hazards. We found these hazards affect five different key socioeconomic systems: livability and workability, food systems, physical assets, infrastructure services, and natural capital.

We ultimately chose nine cases to reflect these systems and to represent leading-edge examples of climate change risk. Each case is specific to a geography and an exposed system, and thus is not representative of an “average” environment or level of risk across the world. Our cases show that the direct risk from climate hazards is determined by the severity of the hazard and its likelihood, the exposure of various “stocks” of capital (people, physical capital, and natural capital) to these hazards, and the resilience of these stocks to the hazards (for example, the ability of physical assets to withstand flooding). We

typically define the climate state today as the average conditions between 1998 and 2017, in 2030 as the average between 2021 and 2040, and in 2050 between 2041 and 2060. Through our case studies, we also assess the knock-on effects that could occur, for example to downstream sectors or consumers. We primarily rely on past examples and empirical estimates for this assessment of knock-on effects, which is likely not exhaustive given the complexities associated with socioeconomic systems. Through this “micro” approach, we offer decision makers a methodology by which to assess direct physical climate risk, its characteristics, and its potential knock-on impacts.

Climate science makes extensive use of scenarios ranging from lower (Representative Concentration Pathway 2.6) to higher (RCP 8.5) CO<sub>2</sub> concentrations. We have chosen to focus on RCP 8.5, because the higher-emission scenario it portrays enables us to assess physical risk in the absence of further decarbonization. (We also choose a sea-level rise scenario for one of our cases that is consistent with the RCP 8.5 trajectory). Such an “inherent risk” assessment allows us to understand the magnitude of the challenge and highlight the case for action. For a detailed description of the reason for this choice see the technical appendix of the full report.

Our case studies cover each of the five systems we assess to be directly affected by physical climate risk, across geographies and sectors. While climate change will have an economic impact across many sectors, our cases highlight the impact on construction, agriculture, finance, fishing, tourism, manufacturing, real estate, and a range of infrastructure-based sectors. The cases include the following:

- For livability and workability, we look at the risk of exposure to extreme heat and humidity in India and what that could mean for that country’s urban population and outdoor-based sectors, as well as at the changing Mediterranean climate and how that could affect sectors such as wine and tourism.
- For food systems, we focus on the likelihood of a multiple-breadbasket failure affecting wheat, corn, rice, and soy, as well as, specifically in Africa, the impact on wheat and coffee production in Ethiopia and cotton and corn production in Mozambique.
- For physical assets, we look at the potential impact of storm surge and tidal flooding on Florida real estate and the extent to which global supply chains, including for semiconductors and rare earths, could be vulnerable to the changing climate.
- For infrastructure services, we examine 17 types of infrastructure assets, including the potential impact on coastal cities such as Bristol in England and Ho Chi Minh City in Vietnam.
- Finally, for natural capital, we examine the potential impacts of glacial melt and runoff in the Hindu Kush region of the Himalayas; what ocean warming and acidification could mean for global fishing and the people whose livelihoods depend on it; as well as potential disturbance to forests, which cover nearly one-third of the world’s land and are key to the way of life for 2.4 billion people.

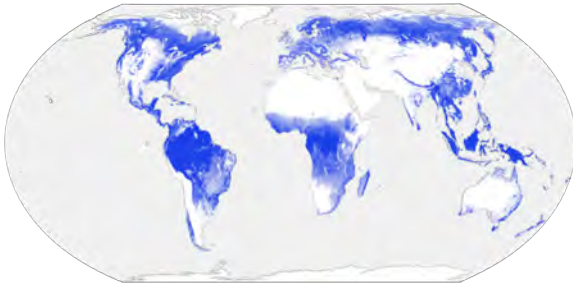
<sup>1</sup> Jonathan Woetzel, Dickon Pinner, Hamid Samandari, Hauke Engel, Mekala Krishnan, Brodie Boland, and Carter Powis, “Climate risk and response: Physical hazards and socioeconomic impacts,” January 26, 2020, McKinsey.com.

## Natural capital can be found all over the globe.

### Forest

Tree density (%)

0 100

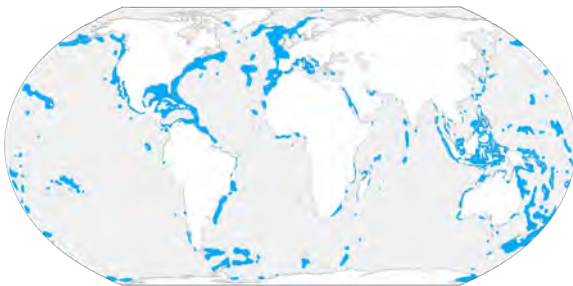


### Fish stocks<sup>1</sup>

0 100



### Coral reefs



### Land ice



### Freshwater

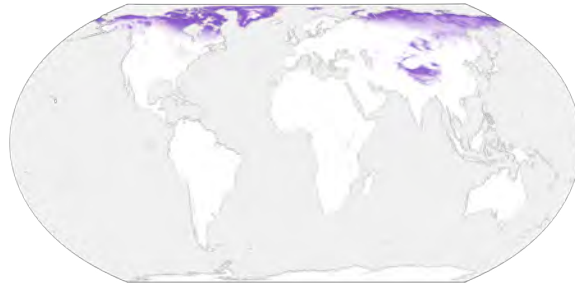
Regions with high freshwater availability



### Permafrost

Permafrost coverage (%)

0 100



1. Index of global fishing activity used as proxy for fish stocks.

Source: Data Basin, 2016; FAO, 2010; Halpern et al., 2015; Hughes et al., 2019; James, *National Geographic*, 2018; Lam et al., 2016; NASA Earth Observatory; UNEP, 2014; Wester et al., 2018; Witt et al., 2014; Zemp et al., 2019; McKinsey Global Institute analysis



world's people depend on glacier-fed rivers for drinking and irrigation water. But glaciers are losing mass at an unprecedented rate in most parts of the world. In the long run, the shrinking of glaciers is expected to reduce freshwater availability, leading to large socioeconomic impacts in sectors such as agriculture, hydroelectricity, and tourism.

Looking closer at the Hindu Kush Himalayan region, we found it faces significant physical and socioeconomic risks as a result of glacial melting. The region covers eight countries, from Afghanistan in the west to Myanmar in the east. Its glaciers provide water for irrigation, energy generation, and other economic activities for the region's 240 million residents and about 750 million people in total. The melting of Himalayan glaciers has doubled since 2000,<sup>2</sup> and more than a quarter of glacial ice in negatively affected regions has been lost in the past four decades. Glacial mass in this region could drop by about 10 to 25 percent by 2030, and by 20 to 40 percent by 2050<sup>3</sup> in some subregions. The region already faces severe danger of catastrophic flooding.

The risk of floods poses an immediate threat to human populations. Climate dependent sectors, such as agriculture,<sup>4</sup> will also be threatened. The consequences could be severe for countries such as India, which has the world's 13th-highest level of water stress and a population three times greater than the total population of the 17 other countries with high water stress. Altered river flows are likely to disrupt food and water supplies and could cause mass population displacements and heighten geopolitical tensions and the risk of conflicts over the management of water and the construction of river dams.

For the Hindu Kush Himalayan region, integrated water planning and management across sectors (such as energy, land, forest, ecosystems, and agriculture) could make water use more efficient and reduce environmental impacts. More water storage could help when discharges are low. Physical protections (such as flood-prevention structures, better irrigation systems, upgraded canals, precision land leveling, and proper implementation and

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<sup>2</sup> J. M. Maurer et al., "Acceleration of ice loss across the Himalayas over the past 40 years," *Science Advances*, June 2019, Volume 5, Number 6.

<sup>3</sup> Philippus Wester et al., eds., *The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People*, Cham, Switzerland: Springer, January 2019.

<sup>4</sup> Jonathan Woetzel, Dickon Pinner, Hamid Samandari, Hauke Engel, Mekala Krishnan, Ryan McCullough, Tilman Melzer, and Sara Boettiger, "How will African farmers adjust to changing patterns of precipitation?," May 18, 2020, McKinsey.com.

**Oceans generate over half of the world's oxygen and currently absorb roughly 30 percent of fossil fuel CO<sub>2</sub> emissions, acting as an important carbon sink that slows the rise in atmospheric CO<sub>2</sub>.**

enforcement of building codes) and management tools (such as land-use planning laws and early-warning systems) are also needed to manage risk.

### **Oceans are warming and undergoing chemical changes, with harmful consequences for marine life and coastal communities**

Covering more than 70 percent of the Earth's surface, oceans provide important ecosystem services.<sup>5</sup> They transport heat between the equator and the poles, which helps regulate the climate and global weather patterns. They generate over half of the world's oxygen and currently absorb roughly 30 percent of fossil fuel CO<sub>2</sub> emissions, acting as an important carbon sink that slows the rise in atmospheric CO<sub>2</sub>. Marine fisheries and aquaculture produce about 15 percent of the animal protein consumed by 4.3 billion people and support the livelihoods of approximately 650 million to 800 million people globally. Coral reefs attract tourists, who generate economic activity, as well as anchoring certain marine ecosystems.

Globally, the rate of ocean warming doubled<sup>6</sup> from 1969–93 to 1993–2017. Ocean warming is increasing the frequency and duration of marine heat waves that can strongly affect marine ecosystems, such as seagrass and kelp forests, which contain significant amounts of carbon. Ocean warming also causes seawater to release stored oxygen. The increasing concentration of CO<sub>2</sub> in the atmosphere causes the ocean to absorb more CO<sub>2</sub>, which makes seawater more acidic. Warming,

deoxygenation, and acidification change the oceans' circulation patterns and chemistry.

Warmer and more acidic oceans have a direct impact on marine species by altering important ecosystem-level processes (for example, primary productivity, reef building, and erosion) as well as physiological processes of marine species and organisms (such as skeleton formation, gas exchange, reproduction, growth, and neural function). Marine creatures, particularly fish and zooplankton, are migrating to higher latitudes, where they engage in seasonal behaviors such as reproduction at different times than in the past. This is having an impact on societies and economies. For example:

#### **Fisheries have been put under stress**

According to one estimate, ocean warming reduced the maximum sustainable global yield of seafood by 4 percent between 1930 and 2010. Yields have fallen by even more in certain areas: in the Sea of Japan and the North Sea, as much as 35 percent. Climate change is forecast to lower fish catches by about 8 percent and associated revenues by about 10 percent or \$6 billion to \$15 billion (including ranges) by 2050 under RCP 8.5.<sup>7</sup>

#### **Coral reefs have suffered from bleaching and subsequent dying**

These impacts have harmed wildlife communities that occupy coral reefs and diminished the habitats of other species. The destruction of coral reefs could also lessen tourism, depriving coastal communities<sup>8</sup> and related sectors of much-needed income. For example, half of Australia's Great Barrier

<sup>5</sup> "Benefits of the Paris Agreement to ocean life, economies, and people," *Science Advances*, February 2019, Volume 5, Number 2.

<sup>6</sup> Gregory Flato et al., "Evaluation of climate models," in *Climate Change 2013: The Physical Science Basis*, Intergovernmental Panel on Climate Change, New York, NY: Cambridge University Press, 2014.

<sup>7</sup> Vicky W. Y. Lam et al., "Projected change in global fisheries revenues under climate change," *Scientific Reports*, 2016, Volume 6, Article 32607.

<sup>8</sup> Jonathan Woetzel, Dickon Pinner, Hamid Samandari, Hauke Engel, Mekala Krishnan, Brodie Boland, and Peter Cooper, "Can coastal cities turn the tide on rising flood risk?," April 20, 2020, McKinsey.com.

Reef's coral has died, and further dying could impede tourism, which accounts for an estimated \$35 billion a year of economic value.<sup>9</sup>

Experts have suggested that mitigating pressures (such as pollution, commercial fishing, invasive species, and coastal habitat modification) could reduce and delay the effects of climate change on the world's oceans. Increased international cooperation could ease adaptation to variation in the productivity of global fisheries. To increase the resilience of coral reef fisheries, experts recommend managing catchment vegetation to improve coastal water quality, maintaining connectivity of coral reefs with mangrove and seagrass habitats, sustaining and diversifying the catch of coral reef fish, and transferring fishing activity to pelagic fish resources. Scientists are investigating measures to restore coral reefs, such as selective breeding, assisted gene flow, conditioning, epigenetic programming, and manipulation of the coral microbiome.

#### **Climate change is exacerbating the pressure on the world's forests**

Approximately 1.6 billion people depend on forests, which cover nearly one-third of the world's land, to make their living. Some studies suggest that forests and trees furnish rural households in developing countries with about 20 percent of their income. Some 2.4 billion people use wood as fuel to cook, boil and sterilize water, and heat their dwellings. Forests also have tremendous ecological importance. They are the habitats for more than three quarters of the world's species, and they store up to 45 percent of all the carbon found on land. And, like oceans, forests act as

important carbon sinks; the biosphere currently absorbs approximately 30 percent of fossil fuel CO<sub>2</sub> emissions, with the majority stored in forests and mangroves.

Researchers studied the link between climate change and forest disturbances due to wind, snow and ice, fire, drought, insects, and pathogens. Their research showed that climate change most likely has a triggering or intensifying effect on disturbances—57 percent of the observations in the studied literature were related to direct impacts of climate change on disturbance processes.<sup>10</sup> Disturbances can also feed back into climate change—wildfires emit large quantities of CO<sub>2</sub> and thus exacerbate the rate of change in the climate.

Because forests take a long time to grow but then live for decades or longer, they are likely to face risks from both changes in mean climate variables and extreme weather events like prolonged drought, storms, and floods. This is especially relevant when considering that fires, drought, and insect activity are likely to increase in warmer and drier conditions. Climate change, a result of human activity, worsens wildfires by making forests hotter and drier.

Forests can be protected by altering forest structures to reduce the frequency or severity of wildfires. It is also possible to maintain wildlife refuges capable of resisting ecological changes and to protect ecologically significant areas such as spawning grounds and highly biodiverse habitats.

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<sup>9</sup> Linwood Pendleton et al., "The Great Barrier Reef: Vulnerabilities and solutions in the face of ocean acidification," *Regional Studies in Marine Science*, September 2019, Volume 31, article 100729.

<sup>10</sup> Rupert Seidl et al., "Forest disturbances under climate change," *Nature Climate Change*, June 2017, Volume 7, Number 6.

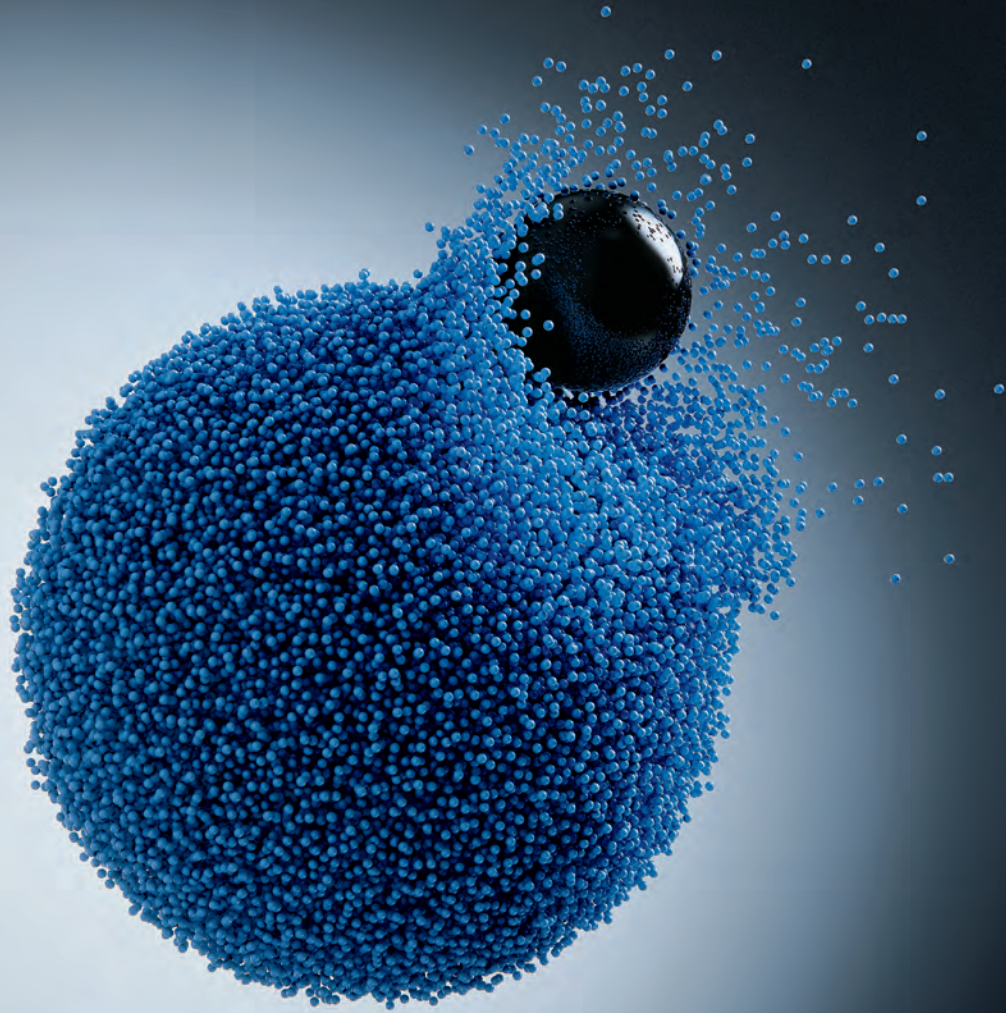
As climate change accelerates, losses of natural capital are expected to mount, reducing ecosystem services and affecting local and national economies. Nevertheless, some solutions can help protect natural capital from climate risks and harmful human activities (such as deforestation), restore depleted natural capital, and limit the socioeconomic impacts of natural-capital losses. Maintaining natural capital and ecosystem services will require more than the

protection of individual stocks of natural capital, such as single species. It will require measures to protect and restore entire ecosystems and, critically, in many instances a coordinated international response, for example in the case of ocean warming.

*[For additional details, download the case study, Reduced dividends on natural capital?](#)*

**Jonathan Woetzel** is a director of the McKinsey Global Institute, where **Mekala Krishnan** is a senior fellow. **Dickon Pinner** is a senior partner in McKinsey's San Francisco office. **Hamid Samandari** is a senior partner in the New York office. **Hauke Engel** is a partner in the Frankfurt office. **Claudia Kampel** is a consultant in the Stuttgart office. **Johanna von der Leyen** is a consultant in the Berlin office.

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CGI illustration by Peter Crowther

# Reimagining mobility: A CEO's guide

No industry or executive is immune to profound implications of mobility's second great inflection point. Here's what you need to know now.

*by Kersten Heineke, Asutosh Padhi, Dickon Pinner, and Andreas Tschiesner*

**Our mental models about mobility**—individually owned cars, gas stations, traffic jams, the driver's license as a rite of passage—are on the verge of disruption. Mobility is about to become cheaper, more convenient, a better experience, safer, and cleaner—not 50 or even 25 years from now, but perhaps within a dozen.

We describe the coming transformation as mobility's Second Great Inflection Point, because it has the potential to be as profound as the one that put horses to pasture and revolutionized industries and societies worldwide. A defining characteristic of the new world taking shape is that the automotive industry, which has operated for more than a century alongside but decidedly disconnected from other components of what transportation has come to mean, will blend into a more interconnected, customer-centric ecosystem. That shift boosts the odds that the momentous changes afoot will affect your business, even if the closest you currently get to a car is your morning commute.

In a companion article, we describe the pressures on the old model, the bursts of innovation (ranging from vehicle autonomy and connectivity to electrification and ridesharing), and the evolving expectations that are propelling us toward the second great inflection point. Here, we drill down on what lies ahead: How exactly will cars, roads, and the customer experience soon be changing? (Think mainstream electric vehicles [EVs]; robots reading maps; interconnected, intelligent infrastructure networks; and, for a growing number of situations, “pay per use.”) What does

that portend for competitive dynamics across the broadening mobility ecosystem? (As profit pools reorder and business models transform, opportunities will arise for a wider array of players, challenging OEMs' notions of their competitive sets.) What are the implications for society, and what speed bumps may we hit along the way? Finally, how should leaders who aren't yet immersed in the mobility revolution prepare for its imminent arrival? Fresh thinking about industry borders, adjacent opportunities, transport and logistics, and partnership possibilities are all needed.

### **Glimpses of the near future**

For the past century, the automotive sector has been siloed—on multiple dimensions. Out of the approximately \$8 trillion to \$10 trillion spent each year on the transport of people and goods, “only” about a quarter comes from what is commonly understood as the car industry. Those businesses are as massive as they are separate. Fuel and energy, financial services such as insurance and financing, and maintenance all represent more than 10 percent of the total pie. You can't use your car without them—and yet they are all disconnected from the automotive industry itself.

Automobiles also are disconnected from one another. Cars cannot be tracked and therefore cannot be guided. Traffic jams are one major result. Another is congestion pricing (fast lanes for those who can afford them). Pollution, made worse from idling and the search for parking, is another severe consequence. Car accidents, injuries, and

**A defining characteristic of the new world taking shape is that the automotive industry will blend into a more interconnected, customer-centric ecosystem.**



fatalities—overwhelmingly the result of human error—occur every day. The second great inflection approaching will break down silos, with profound consequences that start with our cars, roads, and the customers who use them.

### **Cars**

The more interconnected mobility system starts with the cars themselves. Electrification and vehicle autonomy, which are coming fast, stretch the capabilities of traditional OEMs. Less than 5 percent of vehicles sold in 2016 were equipped with EV power trains. Major OEMs have announced that they're aiming to bring that number above 50 percent by 2021.

By 2030, EVs will be mainstream—and not just within the premium segment, as they are today. Nor, for that matter, will EVs be confined to passenger automobiles. Electric buses, trucks, and other delivery vehicles are rolling toward commercialization at an accelerated rate. The changes won't be “one-offs.” To the contrary, they will be magnified by shifts across entire fleets because of the lower costs of electricity as opposed to gasoline, the lower maintenance costs, and the lower overall total cost of ownership.

But that's just the start. In 2016, only about 1 percent of vehicles sold were equipped with even partial autonomous-driving technology. As of this writing, however, eight of the ten largest OEMs plan to have highly autonomous technology road ready by 2025. Google's Waymo has already launched a commercial taxi service made up of autonomous vehicles (AVs), in 2018; Uber plans to do so this year, and Lyft in 2021. By 2030, 80 percent of Chinese, European, and US miles will be at or approaching self-driving. That's not just “hands off the wheel”; it's drivers' minds off the road. Indeed, since the function of driving will increasingly be performed by the car itself, cars will no longer need to be designed around the driver, except to the extent that, through advanced

artificial intelligence, vehicles will be made to intuit what each passenger wants.

In many respects, a car will not even look like a car, at least as we know it today. As Carsten Breitfeld, CEO of China-based luxury EV OEM Byton, points out, without an internal-combustion engine, key elements of the interior (including the dashboard and the center air-conditioning console) can be shifted in radically space-saving ways. With autonomous, connected, and shared vehicles, the changes will go much further. When a vehicle does not need to be designed around a driver, many fundamental tenets of auto design will go by the wayside. Why have a steering wheel? A driver's seat? For that matter, will you need so much steel when safety requirements change? The design possibilities are fascinating—and the second-order effects for nonautomotive industries could be massive.

### **Roads**

Disparate roads and highways—as well as different forms of transportation (buses, trains, airplanes, and even micromobility solutions, such as bicycles and scooters)—will increasingly converge into integrated networks. Early examples are already appearing in Singapore and Barcelona, where strategically placed sensors receive, process, and integrate enormous amounts of data to improve traffic flow, rationalize parking, and keep environs cleaner. Mobile apps such as Germany's moovel and Finland's Whim can now analyze a range of public- and private-transit options to identify the fastest and cheapest route from A to B and let mobile users reserve and pay for their journey. That kind of functionality will be scaled and available for consumers around the world by 2025.

### **Customers**

Ecosystems, by definition, arrange themselves around the consumer. This makes it easier, faster, and cheaper for people to choose what they actually want. Consider, for a car, “freedom” and

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“machine.” Which element matters most? In a highly consumer-centric system, people can have freedom—indeed, even more freedom—without having to buy their own vehicles, search for parking, and pay for fuel (and a list of other expenses). Order pizza, get to work, take the family to the beach—when these use cases can be addressed with a swipe, the make or model of the car involved may matter less.

What will matter—what has always mattered—is customer experience. As more people come to “consume mobility,” that experience will include:

- on-demand, pooled autonomous ridesharing as a part of the public-transportation system
- mobile games for commuters to play against one another en route, while the data generated by those games is used to help optimize traffic in real time
- more vehicles on the road moving more quickly, sped along by a municipality's intelligent traffic-management tools
- air-quality sensors, which track specific sources of pollution and regulate traffic and construction accordingly

That's fact, not fantasy. These examples are starting to happen in major cities around the world.

## Competitive dynamics

In the past, OEMs competed primarily with one another. In the years ahead, consumers will focus more on different mobility operators, intensifying competition between OEMs and other mobility providers on dimensions such as utility of the interior, quality of the service, and sophistication of the connected-car experience.

Those new competitive dynamics will take place in the context of drastic changes in the economics of mobility. Today, OEMs are making about one cent in profit per mile driven. New mobility services have the chance to up this by a factor of ten to 25. Automotive companies are also very well positioned to capture monetization opportunities from car data. Our research finds that, so far, automobile consumers around the world are highly willing to share their data when they experience value in return.

That said, it won't be easy to gain a defensible position across the critical technologies of autonomy, connectivity, electrification, and shared mobility. By our analysis, a company would have to invest nearly \$75 billion, much of it going toward electrification and autonomy, to do so. While the new technologies will doubtless generate enormous value, no one can say where the economic profit will flow—and when. At any inflection point, value shifts quickly and unpredictably, and consumers tend to capture more of it.

This is especially so in the digital age. Encyclopedias, newspapers, camera film—when products turn into services, people pay a lot less. In fact, they may not pay at all. In the United States alone, the internet provides consumers about \$100 billion of free welfare gain every year. It's quite possible that a similar dynamic will play out as mobility becomes less about the car and more about a service. As happened with the mass adoption of both the internet and smart mobile devices, the life changes will seem almost imperceptible at first—then overwhelming, and inevitable.

### Societal shifts

An inflection point is not an end point. It's a redirection—the launch of a new trajectory. We can already see the pace of change begin to quicken. EVs, outside of the premium segment, have become commercially relevant only within the past three to five years. As late as early 2013, few were searching for “Uber” on Google.<sup>1</sup> Carsharing was novel, too. Developments such as these will further speed up the change dynamics, both because adoption is driven by B2B and B2G enterprises rather than B2C businesses and because “ticket size” is much smaller.

The sum of individual decision making—choosing to pay fractions for a trip instead of many thousands for a car—will have enormous effects in the aggregate. Just as mobility's first great inflection point reshaped society in ways initially unimaginable, the changes this time will reach far beyond the cars we drive (and increasingly, the vehicles in which we are driven). Those effects could include:

- **Where people live.** If things break right, commutes will be faster. Suburbanization will increase in many areas, a consequence of the

first great inflection point once again in vogue.<sup>2</sup> At the same time, because in-city congestion will be more manageable and parking less of an issue, urbanization—especially among younger people—will rise even faster.

- **How people live.** Riders will be safer and will have more free time, both during their journeys and as a result of the cumulative hours saved from digitally connected roads driven by AVs that are optimally paced, optimally spaced, and free from human error. Commutes will no longer be an exercise in frustration. In fact, work itself will change. As more people become able to start their workdays in the car, commuting time will increasingly count toward the eight-hour workday—enabling people to spend more time on other things, or more time working. Our colleagues estimate that the time saved by commuters worldwide could add up to a staggering one billion hours—every day. That's twice the working hours it took to build the Great Pyramid of Giza.
- **How people consume.** The separate steps between contemplating a purchase and actualizing it will be compressed into a few swipes. Mobility has always had enormous implications for retail (the first pizza delivery was made in the 19th century). Just as Amazon has had the effect of increasing volumes shipped, a more integrated mobility ecosystem will make near- and far-distance purchases easier and faster. It will also make them cheaper: our colleagues in McKinsey's Consumer Packaged Goods Practice estimate that fully autonomous vehicles could reduce grocery-delivery costs by 50 percent. With OEMs, ridesharing providers, and others investing significantly in solving the “last mile”—or “last 50 feet”—link of mobility, customer

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<sup>1</sup> Google Trends, [trends.google.com](https://trends.google.com)

<sup>2</sup> Justin Fox, Conor Sen, and Noah Smith, “Millennials are driving the suburban resurgence,” *Bloomberg*, August 25, 2017, [bloomberg.com](https://www.bloomberg.com).

satisfaction will greatly increase. Consumers will come to use AVs to shop for everything from groceries at the local supermarket to accessories at the Apple Store downtown.

- ***What life looks like.*** When London experienced its precar “Great Horse Manure Crisis,” in 1894, there were 50,000 horses in London; find one there today, and you have found a tourist attraction. Just as the car transformed what the world looked like after the first great inflection point, our world will change, too. Slowly at first, but then much more rapidly, we will see gas stations, parking lots, and traffic jams become things of the past. Fumes and emissions will diminish. “Big digs” for mass transportation will be scaled down as well, since on-demand AVs can be at least as efficient. Air and ground shipping could converge if delivery drones and droids become mainstream. All in all, life should be greener, cleaner, safer, and, we expect, better.

Still, changes are rarely seamless, and big changes can be especially bumpy. Net-net, the benefits will decisively outweigh the costs. The harder question ultimately is not whether these changes will happen (they will) or when they will start (in many cases, they already have) but what the best ways to manage the transition are.

The shift to a mobility ecosystem will doubtless hit some speed bumps. Some of these we can probably foresee and, ideally, prepare for, such as cyberattacks on transportation systems or accidents resulting from systemic failures. Additional risks—more likely earlier in the inflection—include the perception of major failures and the unfortunate tendency for a wired-in, social-media world to sensationalize small incidents beyond reasonable proportion. The loss of millions of jobs for truck drivers and

taxi drivers is unquestionably a cost, even as the transformation will create a range of new employment opportunities with potential for higher earnings and greater value creation, such as AV and EV technicians, and even trained attendants for disabled and elderly persons traveling by AV.

Finally, beyond any futurist’s vision are the “unknown unknowns.” Is there such a thing as being too connected? How will geopolitics realign if oil is no longer the prize? What comes next in our collective imagination when stylish rides are replaced by more utilitarian use cases? Sooner or later—and probably sooner—we will find out.

### **A call to action**

As the second great inflection takes hold, many businesses that do not consider cars to be close to their core industry will find themselves confronting an increasingly far-reaching mobility ecosystem.

There are some obvious first-order effects, starting with how business gets done. Logistics costs will be reduced—in certain cases, dramatically (our colleagues estimate that autonomy in delivery could reduce costs by upward of 40 percent). Long-haul routes will be shortened, too, as 3-D printing reduces the need for some long-distance shipments. Shippers can transport to fulfillment centers or urban drop-off zones, and smaller, purpose-built AVs will be able to handle things from there. Moreover, businesses will be able to become more agile—a capability that they will need in order to meet the demands of their customers, who will expect more products more quickly.

But the implications of the second great inflection point extend much further. Within a decade, the developments we’ve been describing will start having strategic ramifications for a

wide array of companies. Here are some early priorities for everyone:

### **1. Adjust your sideview mirrors**

Clear industry borders and siloed business sectors won't stay that way for long in the new mobility ecosystem. For leaders outside of the automotive, transportation, or energy sectors, those changes can spell both threats and opportunities. Threats, because new competitors and attackers can appear from wildly unexpected directions: just consider the impact that advanced digital mapping had on publishers such as Rand McNally or, for that matter, the consequences that a growing market for EVs can have on the prices of laptop computers (the batteries of both rely on lithium, which tripled in price over a recent ten-month period). And opportunities, because the expanding mobility ecosystem can bring new customers and markets.

The first order of business is to figure out your role in the new mobility ecosystem. Ask yourself and your team where your business might fit in this new landscape—and who else might be entering the picture (for more, see sidebar, “Can auto insurance—and insurers—keep up with the changing nature of mobility?”). Focus on your core sources of value and key customer relationships. How can these be used to your advantage in a multidimensional game? The onus to scenario-plan can't be on the C-suite alone. Encourage those closer to the front lines to do the same. Expect some internal resistance—“our business has always been this way.” It's hard to get your team to think and act creatively to prepare for the threats and opportunities of the coming inflection point, and simply passing along the information won't cut it. Embolden your employees to imagine what they would do differently under different circumstances. Incentivize them to get in front.

### **2. Objects are closer than they appear**

Does it seem like just yesterday that you saw your first iPhone? So near in time—and yet such an epochally different world. Keep that frame of reference in mind as you prepare for mobility's second great inflection point. Relatively speaking, it won't be long before AVs deliver at a click, commuting patterns change, and car travel becomes “always on” and “wired in.” To a surprising degree, we know the future; we just don't know—and are more likely to under- than overestimate—how soon it will arrive. Take advantage. Test out pilots where you can gain knowledge in connected businesses (there's no lesson better than first-hand experience); track your progress with actionable timelines and incentives; and acquire and develop talent prepared for the coming changes.

### **3. Merge ahead**

Both the fluidity of ecosystem dynamics and the agility needed to meet customer needs rapidly mean that your competitors—present and potential—may be active in different business models and multiple technologies. No single player will have the resources or capabilities to capture, defend, and win in manufacturing, designing, mechanical engineering, software development, artificial intelligence, and all the other areas associated with the mobility changes. Meeting your customers' needs will require serious collaboration, which many companies aren't prepared for. Start by identifying the “white spaces” you need to fill, the partners that can best help with those gaps, and the “gives” and “gets” genuinely required. Most of all, think strategically about how to best position yourself—and with whom.

### **4. Share the road**

Social factors have always been a significant part of the mobility equation. Henry Ford prioritized an

## Can auto insurance—and insurers—keep up with the changing nature of mobility?

by David Hamilton, Kurt Strovink, and Kaitlyn Young

**The coming mobility shift** will have disruptive implications for auto insurers. Self-driving features should lead to safer cars, fewer accidents, and, ultimately, to lower premiums. It's also possible that fewer people will own cars, with on-demand services making ownership an option, not a requirement, for more people. Those passengers may need different, short-term policies, not year-long comprehensive coverage. And over time, driverless cars could place more of the safety onus on manufacturers than on “drivers.”

While the precise timing and extent of these changes is still hazy, it seems all but certain that auto insurers' traditional premium pools will decline in the future. The exhibit below illustrates the impact of different autonomous-vehicle adoption-

rate assumptions on premiums—which, in any scenario, are unlikely to be dramatically affected for a decade or so, but then could weaken rapidly.

So even as insurers strive, in the near term, to make their businesses hum amidst relative stability, they must simultaneously create options and reallocate resources to boost the odds of thriving when the inevitable inflection takes place. Consider, for example, insurers' ownership of car-safety data. While currently a source of strength, it could prove tenuous as automotive OEMs build more real-time connections between cars and consumers—suggesting a need for increasingly sophisticated data strategies. Many insurers also have near-term opportunities to digitize and

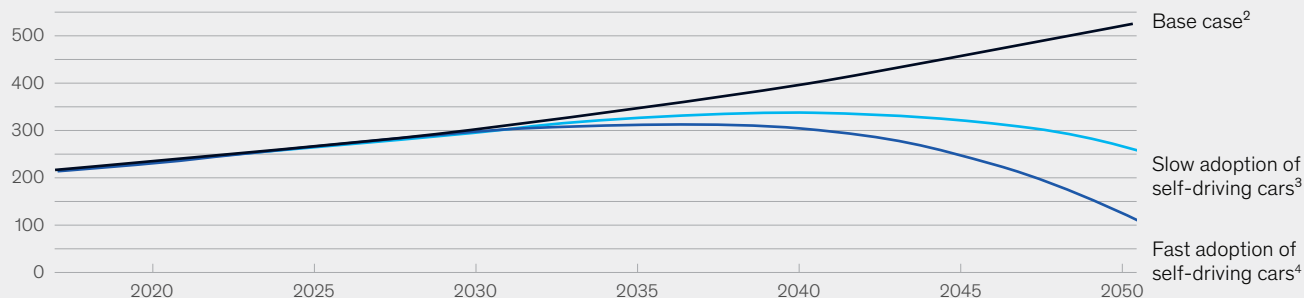
automate their businesses, thereby creating savings that can be redeployed to fund improved understanding of likely trends and consumer behaviors in the emerging mobility ecosystem. And now is the time to start exploring and investing in the products and partnerships of the future. One possibility: working with fleet providers to offer “part-time” insurance that consumers can buy via apps on their phone when they hail a ride. Another example would be partnering with OEMs to own the risk of manufacturer fault.

The opportunity—a broadening of the insurer's role—is significant, and so are the dangers. The race is on to define a path connecting today's realities with tomorrow's uncertainties.

Exhibit

### The rate of decline in auto-insurance premiums will depend on how quickly self-driving cars are adopted.

US premium revenue,<sup>1</sup> in real dollars, \$ billion



<sup>1</sup> Assumes self-driving cars are introduced in 2022, producing a 90% drop in accident frequency and a 50% rise in paid-damage severity.

<sup>2</sup> Base case assumes historic 2.7% annual growth of auto-insurance premium continues with no technology impact.

<sup>3</sup> Slow adoption projects self-driving cars comprise 3% of all cars in 10 years, 20% in 20 years, and 60% in 30 years.

<sup>4</sup> Fast adoption projects self-driving cars comprise 5% of all cars in 10 years, 35% in 20 years, and 90% in 30 years.

Source: National Highway and Rand data; previously reported adoption rates; Schedule P data; McKinsey analysis

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## How Progressive CEO Tricia Griffith is preparing for the future of mobility

**We certainly can't** predict the future, but we're actively tracking and continuously studying not just autonomous technology but the wide range of new technologies that are being developed, to understand how they'll impact our customers and insurance-loss costs. We also are closely tracking the evolution of mobility trends such as subscription services. While it's not yet clear how quickly these emerging models will displace traditional vehicle ownership, we're taking steps to position our business to learn about these changes. For example, we are a leading commercial insurer of Uber for their ridesharing platform.

One advantage we enjoy is lots of data. Through Snapshot, our data-collection

engine, we've amassed more than 25 billion miles of trip data, which has shown us that driving-behavior data is the most predictive variable we have for auto-insurance pricing. Additionally, we work with original-equipment manufacturers, third-party intermediaries, and a variety of other key stakeholders to ensure we gain immediate insight into what's next in the industry—so we can project out accordingly and stay ahead of the curve. That includes integration between Snapshot and GM's OnStar program, and participating in the University of Michigan's Mcity, which is an autonomous- and connected-car R&D initiative. All that helps us to learn about new technologies, new methods of data collection, new driving behaviors, and their potential impact on the insurance industry.



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affordable wage and created a base of loyal car-buying employees, which had a multiplier effect on sales. Environmental responsibility turns EVs into premium brands. And Waze built its business by building a community. As the second great inflection point approaches, social considerations and public-private cooperation will take on outsized importance. Consider safety protocols, for example: no single player will be able to set the safety standards alone; nor can a government simply dictate them without a deep understanding of player capabilities. Or pooling and robo-shuttles for people and goods:

governments and communities will determine mundane but mission-critical details, such as designated pickup, drop-off, and parking spaces. To win in the second great inflection point, develop a well-considered perspective on present and future regulations. And more: Think about how your success ties into the benefit of others. Ecosystems are inherently interconnected. Those that bear societal considerations in mind will be the most connected of all.

As mobility becomes cheaper, more convenient, more attuned to human and business experience, cleaner, and safer, business and society will be transformed. We've seen seismic change of that order unleashed when Henry Ford popularized mass production and Alfred Sloan took the organizational construct to new levels. The 20th-century disruption was swift and certain—not

just for carmakers but for businesses around the world. Yet few saw those changes approaching. Now, about 100 years later, we're at the precipice of a second great inflection point. While much uncertainty remains, the transformation is, in many respects, already here. It's clear that those who aren't prepared will risk failing one of the 21st century's early tests.

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# How solar energy can (finally) create value

The market for solar power is growing faster than ever, but profitability has been lagging. The keys to improvement are better capital and operational efficiency.

*by David Frankel, Aaron Perrine, and Dickon Pinner*

**Solar energy** is becoming a force to be reckoned with.

Last year, China and the United States installed a record 15 and 7.5 gigawatts (GW) of solar, respectively. This year, the world could install as much as 66 GW.<sup>1</sup> In 2015, investors poured \$161 billion of capital into solar, the largest amount for any single power source.<sup>2</sup> In China, 43 GW of capacity have been installed, more than in any other nation; India aspires to build 100 GW of solar capacity by 2022. Across the sun-drenched Middle East, investment rose from \$160 million in 2010 to about \$3.5 billion in 2015.<sup>3</sup>

The world is building more solar-power plants because they are getting cheaper. Since 2009, the total installed costs of solar have fallen by as much as 70 percent around the world. New power purchase agreements frequently fall below \$100 per megawatt-hour, with some reaching less than \$30.<sup>4</sup> That price puts solar at or below the cost of a new natural-gas plant. Regulatory measures, such as the Investment Tax Credit in the United States, further support the economics of solar. In many instances, solar is often “in the money”—that is, less costly than the next cheapest alternative. A number of leading multinationals are signing solar deals not only to gain green credentials but also to lower their energy costs and diversify their sources of supply. Given these trends, we believe that 2,000 to 3,000 GW of solar capacity—or almost half of total electric-power capacity in the world today— will be economic by 2025. Of course, solar can’t fully meet the need for electricity on its own because (among other reasons) the sun doesn’t always shine, so not all of this will be built. But a significant portion will. And that growth will transform energy markets around the world.<sup>5</sup>

Although the future is bright, many solar companies are struggling. Downstream providers—the developers and builders of solar-power plants—have pursued growth and market share but struggled to deliver profits. In the United States, valuations of some companies fell drastically in 2015 and 2016, and there have been a number of high-profile restructurings and bankruptcies, possibly with more to come.

Macro factors also play a role. Low oil and gas prices have tested solar’s competitive position. The threat—though perhaps now more distant—of higher interest rates is another negative factor because the economics of solar projects are sensitive to the cost of capital.

In spite of these issues, we believe opportunities for growth and profit exist throughout the solar value chain. To survive the current market conditions and prosper in the longer term, downstream businesses in particular need to overcome two major challenges.<sup>6</sup>

## The challenge of project margins

As more companies enter the market for solar projects, competition intensifies—and profits narrow. The solar industry is relatively young, so construction costs vary widely, with some firms experiencing severe overruns. To maintain attractive margins, the best players will drive down the cost of building a plant faster than the industry average, allowing them to grow and take market share. To do so, they must address system design and construction execution.

<sup>1</sup> “Led by China, the United States, and Japan, global solar installations to reach approximately 66.7 GW, reports Mercom Capital Group,” Mercom Capital Group, April 2016, mercomcapital.com.

<sup>2</sup> *Global trends in renewable energy investment 2016*, Frankfurt School–United Nations Environment Programme (UNEP) Collaborating Centre for Climate & Sustainable Energy Finance, March 2016, fs-unep-centre.org.

<sup>3</sup> Raed Bkayrat, *Middle East solar outlook for 2016*, Middle East Solar Association, May 2016, mesia.com.

<sup>4</sup> “Follow the sun,” *Economist*, April 16, 2016, economist.com.

<sup>5</sup> Compared with nuclear or fossil-fuel plants, solar has a much lower capacity factor—the ratio of actual to potential output—of 15 to 34 percent. Solar therefore generates fewer units of energy for every unit of capacity.

<sup>6</sup> We recognize that there also are challenges related to integrating solar with the electric-power grid in a cost-effective, fair, and technically efficient way. These topics are outside the scope of this article.



**System design.** Systems for solar are typically designed from the bottom up. Each power plant or roof gets the perfect answer, a process that translates into high costs for labor and production. It doesn't help that the solar supply chain is immature, and the technology itself is still evolving rapidly. Many of the sector's engineering, procurement, and construction (EPC) companies are small, with limited solarspecific capabilities.

As the industry scales up, players should develop systems based on prefabricated components that are a very good, but not perfect, fit for a wide range of sites and that will integrate easily in the field—an approach known as “design for constructability.” In addition, automation and aerial site assessments can speed up design prototyping and help firms make more accurate estimates before they put boots on the ground (or the roof).

In the case of large utility-scale projects, better up-front assessments of ground conditions can minimize rework for pile driving or trenching. Developers could prefabricate off-the-shelf units, making it possible to install them in hours rather than days for rooftops, or in weeks instead of months for large ground-mounted systems. To achieve this goal, firms will have to overhaul their supply chains to ensure that components can work with one another and should collaborate closely with EPC companies to create and deploy cost-saving ideas. The automotive industry, which uses standard designs over and over for different models, is a helpful analogy. Similarly, big-box retailers often use a handful of standard designs for their stores.

**Construction execution.** Traditionally, construction performance has taken a back seat to project development. But from now on, as the industry scales up and the number of projects grows, solar companies must pay more attention to execution.

Many of them struggle to finish projects on time and on budget; the resulting delays and cost overruns damage profitability and capital management. Ultimately, projects are at risk if they miss deadlines for operations and for connections to the power grid.

Photovoltaic (PV) solar plants are not nearly as complex to build as other types of power plants. Even so, firms need contracting strategies that align their own incentives with those of their construction partners across the life of each project and that standardize execution in the field. Owners should be able to monitor progress and capture performance data to learn alongside their EPC partners. Larger players also need to implement lean-construction techniques to increase productivity and decrease labor costs.

Solar players need to bring these pieces together and aggressively manage costs in each area. A detailed cost road map can help to reduce costs and develop a realistic forward cost curve against which developers and sales teams can bid for future projects. An effective cost analysis begins with setting goals, based on the levelized cost of energy for each market. Then, each cost component should be mapped, targets set, and a portfolio of improvement initiatives developed and tracked.

## **The challenge of capital flows and balance-sheet strength**

It's a Catch-22: prudent solar companies cannot afford to scale up beyond the strength of their balance sheets, but most have relatively weak ones. Only by getting bigger, and thus having more collateral in the form of projects, can they bolster their financial positions and scale up. Solar companies must therefore find new ways to attract longterm capital from institutional investors (either through public markets or private placements), to improve capital efficiency, and to forge prudent growth strategies.

*Unlock long-term capital markets.* Completed solar projects are attractive for investors seeking dependable long-term cash flows. The challenge is how to resolve the lower cost of capital (less equity, more debt) for an operating plant with the higher cost of capital (more equity, little debt) for developers. One approach has been the use of “YieldCos”— entities that purchase completed projects and have balance sheets separate from the development company. Assuming they are focused on delivering low-risk, stable cash flows, these

entities should enjoy a much lower cost of capital and higher levels of leverage, and thus could provide the liquidity developers need to grow. Similarly, solar-development companies, or “DevCos,” should be equity focused, with low levels of debt.

But for various reasons, YieldCos have not met the needs of institutional investors. There have been issues related to transparency and governance; those owned by developers sometimes presented conflicts of interest. Also, the marketing of YieldCos

## Key questions for the US distributed solar industry

**The distributed solar market** in the United States is challenging. The industry must answer several key questions to ensure continued growth.

### **What regulatory model will prove sustainable?**

Net energy metering, which allows solar owners to sell back power to the grid at the retail rate, is proving expensive and does not reflect the full value the grid provides. Market structures must be developed that ensure everyone pays an amount commensurate with the value of the specific services they use, including grid access, energy, reliability, and interconnection. In turn, this will drive sustainable capital formation for distributed solar.

### **What will it take to cut customer acquisition costs to sustainable levels?**

Lowering customer-acquisition costs

requires better knowledge and more efficient go-to-market models for targeting and acquiring customers. It may also involve forming partnerships with utilities and communities to increase installation density.

### **Will ‘tax equity’ finance continue to be the US standard?**

The system of tax-equity finance creates market inefficiencies, especially since neither solar players nor utilities have a lot of tax capacity. Capital structures that are more transparent to customers and simpler to execute must be developed.

### **How can distributed solar players shorten the cash cycle?**

The lag time from order to installation to grid connection to cash can be six months or more for a job that takes a day for residential customers and, at most, a few weeks for commercial or industrial ones.

Project-delivery models, built on standard designs and construction excellence, must be developed and then scaled up.

### **How can incentives be improved to install solar where it will be most valuable?**

The market is building most residential solar in high-income zip codes. The value of solar to the grid is much higher, however, in resource constrained areas and areas needing grid upgrades. Incentives for new installations must begin to reflect these locational (or “nodal”) values.<sup>1</sup>

If the industry does not address these questions, the business models of both solar installers and utilities are likely to come under pressure, with possible restructurings and regulatory disallowances.

<sup>1</sup> Solar is not always the most appropriate type of distributed energy resource. Depending on the situation and load shape, storage, demand response, and energy efficiency should also be considered to capture “nodal” value.



as growth vehicles—that is, entities meant to provide long-term stable cash flows, not growth—and the quality of underlying assets have been problematic. As a result, many are valued well below their initial-public-offering levels. Similarly, when DevCos take on significant levels of debt, problems can occur, because the cash flows associated with project sales are inherently less predictable.

Institutional investors want a healthy yield at low risk; solar developers want a dependable way to liquidate higher-cost equity capital to reinvest it in the next project. A “YieldCo 2.0” should be developed to meet the needs of both parties, with a transparent, simple governance structure that provides both an attractive home for long-term capital and sufficient flexibility to project developers. Similarly, a pure-play “DevCo 2.0” should be focused on equity, without a great deal of debt.

Several new ideas, including private “PoolCos” that invest on an asset-by-asset basis, look promising but have yet to be fully tested. Such innovative solutions to the industry’s financing challenges could bring substantial rewards. We believe markets will test and scale new ways to meet the industry’s capital needs.

**Improve capital efficiency.** Working capital turns matter: every dollar deployed needs to achieve maximum impact. Companies that hope to succeed must carefully choose the parts of the value chain and the customer segments and geographies they want to play in, so that capital doesn’t get locked up in low-margin uses for long periods. They should also pursue forms of low-cost financing, such as project debt and trade credit (for example, from module manufacturers) to leverage equity returns.

At the same time, solar developers must manage their cash and overall cash-to-cash cycle—a task not for the faint of heart. For example, companies

should track expected cash inflows and outflows at a very detailed level and resist the temptation to push out payment dates, particularly if smaller vendors may not be able to cope with stretched-out payments.

Finally, it’s important to have a systematic yet flexible approach. For example, utility-scale developers may find that some projects earmarked for long-term ownership should be sold earlier to fund equity checks needed to complete other projects.

**Build sustainable growth strategies.** Solar firms must figure out how to scale up without becoming overextended. Possible strategies include using small, local teams to focus on higher-margin geographies; exploring capital-light strategies for market entry, such as partnerships and joint ventures; becoming an independent power producer over time by retaining stakes in projects once they go into operation; and managing currency exposure and the risk of trapped cash.

## Getting back to fundamentals

Meeting these challenges will not be easy. Developers with middling balance sheets or management teams that have focused more on growth than on profitability may now need to pay greater attention to managing liquidity and, in some cases, to avoiding bankruptcy.

In 2015 and 2016, the solar industry has seen significant value erosion, and matters could get worse before they get better. But the sector has proved its resilience before, recovering from both the 2008 financial crisis and the 2011 shakeout. Moreover, the trends that favor the continued growth of solar power—falling costs, improving technology, and regulatory support—are gaining strength. The fundamentals of solar projects are attractive. Over time, solar PV will become one of

the cheapest sources of power and possibly the cheapest of all. Developers, however, will capture value only if they return to fundamentals to bring down the total cost of installed systems, manage the cost of capital, and improve operations.

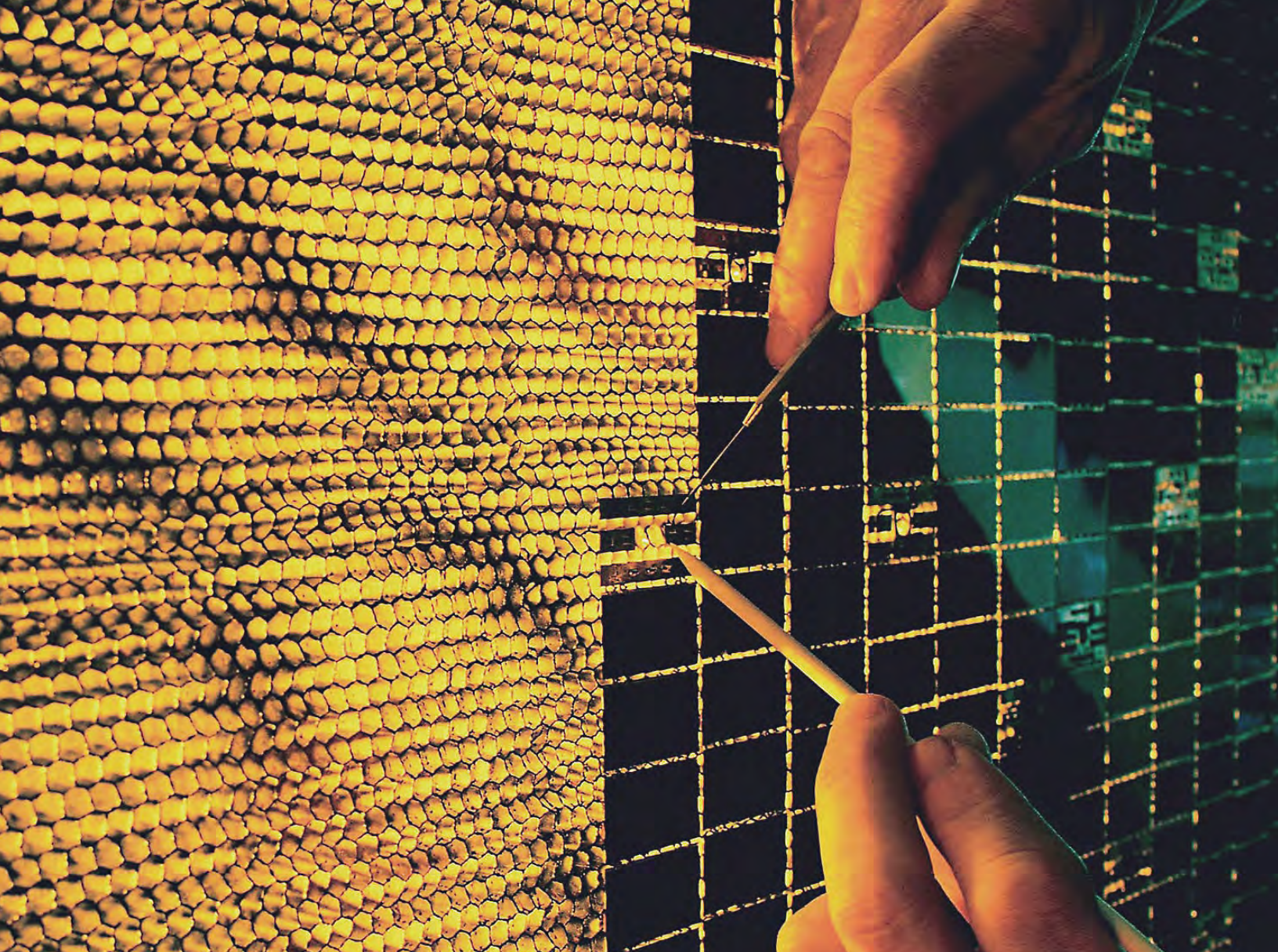
companies to figure out how to generate not just clean energy but also good financial returns. For those that do, the rewards could be tremendous. Those that don't may not survive.

The next critical step for the solar industry, then, is not so much technical as economic: it is time for

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# Brave new world: Myths and realities of clean technologies

Don't be fooled by high-profile setbacks. The cleantech sector is gaining steam—with less and less regulatory assistance.

*by Sara Hastings-Simon, Dickon Pinner, and Martin Stuchtey*



**The world** is on the cusp of a resource revolution. As Stefan Heck and Matt Rogers argue,<sup>1</sup> advances in information technology, nanotechnology, materials science, and biology will radically increase the productivity of resources. The result will be a new industrial revolution that will enable strong economic growth, at a much lower environmental cost than in the past, thanks to the broad deployment of better, cleaner technologies and the development of more appropriate business models. But how do we reconcile this heartening prediction with recent challenges experienced by cleantech, the general term for products and processes that improve environmental performance in the construction, transport, energy, water, and waste industries? Over the past couple of years, many cleantech equity indexes have performed poorly; in January 2014, the American news program *60 Minutes* ran a highly critical segment on the subject. The former chief investment officer of California's largest public pension fund complained in 2013 that its cleantech investments had not experienced the J-curve: losses followed by steep gains. It's been "an L-curve, for 'lose,'" he said.

So, is cleantech failing? In a word, no. Rather, the sector has experienced a cycle of excitement followed by high (and often inflated) expectations, disillusionment, consolidation, and then stability as survivors pick up the pieces. We've seen this before with other once-emerging technologies such as cars, railroads, elevators, oil, and the Internet. Much of cleantech is just leaving its disillusionment or consolidation phase. For example, in transport, Tesla Motors is looking good, while Fisker went into bankruptcy in 2013. In energy, SunPower is making healthy margins, and SolarCity raised \$450 million in 2013, but more than a hundred other solar companies are now gone. The shakeout is brutal— and typical. It has weeded out weaker players, making the industry as a whole more robust. Despite this rough patch, annual growth is at double digit rates.

It's also important to look beyond financial statements. Global wind installations, for example, have soared about 25 percent a year since 2006 (exhibit). And global commercial investments in clean energy have more than quintupled, from nearly \$30 billion in 2005 to about \$160 billion in 2012. Even countries with vast reserves of oil and coal—in the Middle East and Central Asia—recognize that they can't miss out and are developing substantial programs for renewables. Meanwhile, the average real cost per oil well has doubled, and new mining discoveries have been flat, despite high investment. And, clearly, new ways are needed to meet the needs of the 1.3 billion people who lack electricity and the 2.7 billion who rely on traditional biomass, such as wood and dung, for cooking.

Cleantech is no passing, unprofitable fad. The sources of underlying demand—a growing middle class around the world and resource constraints<sup>2</sup>—aren't going away, and cleantech could be pivotal in dealing with both. There are three major myths that undermine confidence in cleantech's future.

### **Myth 1: Deployment and influence will be marginal**

This is not so, and we know that because we see what is actually happening. According to the International Energy Agency, renewables already accounted for 18 percent of global consumption in 2010, and they are growing faster than any other form of energy. Given the radically lower marginal costs of renewables, their position is even more promising over the long term. In fact, the International Energy Agency predicts they will account for more than 60 percent of new power-plant investment to 2035.

The effects of clean technologies will vary significantly by industry and geography. In some cases, they may truly transform markets, as light-emitting diode (LED) technology is now doing in

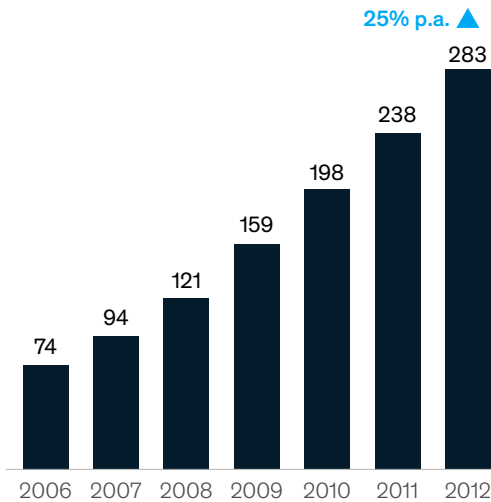
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<sup>1</sup> For more on this argument, see Stefan Heck and Matt Rogers, "Are you ready for the resource revolution?," *McKinsey Quarterly*, March 2014, mckinsey.com. This summarizes some of the ideas in Heck and Rogers's new book, *Resource Revolution: How to Capture the Biggest Business Opportunity in a Century*, first edition, New York, NY: New Harvest, April 2014.

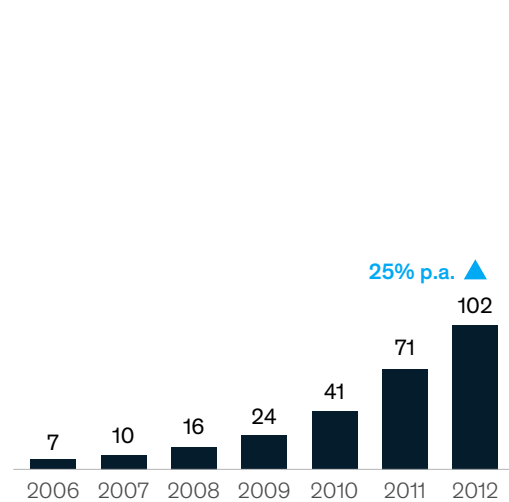
<sup>2</sup> See Richard Dobbs, Jeremy Oppenheim, and Fraser Thompson, "Mobilizing for a resource revolution," *McKinsey Quarterly*, January 2012, and *Resource Revolution: Meeting the world's energy, materials, food, and water needs*, McKinsey Global Institute, November 2011, both available on mckinsey.com.

## Many clean technologies have seen a high rate of growth in installed capacity since 2006.

**Global cumulative installed wind capacity, 2006–12, gigawatt (gW)**



**Global cumulative installed solar-photovoltaic capacity, 2006–12, gW**



Source: Bloomberg; Dow Jones; *Global Market Outlook for Photovoltaics 2012–2017*, European Photovoltaic Industry Association, May 2013; Factiva; Global Wind Energy Council; Thomson Reuters Datastream

lighting. In cases where penetration rates are lower, they can still have a dramatic impact on industry structures and market dynamics. Among US electric utilities, for example, the traditional business model relies on putting capital in the ground. But the potential of distributed solar generation to meet the majority of new demand growth can upend that model entirely. As more people install solar panels on their roofs and add new capacity, demand will increase more slowly for utilities. Some utilities are responding to this by trying to get regulators to allow them to include investments in energy efficiency or renewables in their rate base. In addition, shale gas, which already makes up about 40 percent of gas production in the US (largely at the expense of coal-fired generation), has lowered the wholesale price of

power, cutting into revenues and profit margins for deregulated utilities.

It's important to remember, too, that the cleantech space is diverse; it cannot be painted with a broad brush. We looked at 16 important clean technologies<sup>3</sup> and found that while every single one has made progress over the past decade, some are moving much faster than others. Just over half of them—advanced building technologies, advanced agriculture, food life-cycle optimization, grid analytics, grid-scale storage, intelligent transport, next-generation vehicles, solar photovoltaics (PVs), unconventional natural gas, and water treatment—could become truly disruptive to the incumbent industries. The others have enormous potential and

<sup>3</sup> Advanced building technologies, agriculture (seeds, pesticides, drought resistance), biopower, grid analytics, next-generation vehicles, solar photovoltaics, unconventional natural gas, waste recycling, wind, advanced biofuels and bio-based chemicals, carbon capture and storage, food life-cycle optimization, grid-scale storage, intelligent transport, smart water sensors, and water treatment.

could well succeed, but without disrupting the status quo.

## **Myth 2: Technologies have underdelivered**

Profit margins have certainly been squeezed in some areas. For instance, Chinese production of solar panels has pushed many higher-cost producers in the Europe and United States out of business. In other cases, limited access to capital and decreasing subsidies have slowed deployment. And many big incumbents have scaled back their cleantech investments.

Yet cleantech has far exceeded expectations in many areas; technological innovation and manufacturing improvements have driven prices down. Costs for onshore wind, solar PV, and lithium-ion batteries have all fallen faster than many industry watchers anticipated, for example, and are continuing to drop. The cost of electricity from onshore wind facilities is half what it was 15 years ago, thanks to technological innovation and business-model changes. In the lighting market, LED gained market share as manufacturing costs and prices fell; over the past five years, the cost of superefficient LED lights has fallen by more than 85 percent. We estimate that the cost of electrical storage has fallen by roughly half, from \$1,000 per kilowatt-hour to \$500 per kilowatthour, since 2009. Similar shifts are taking place in less prominent sectors, such as water reuse, waste separation, and anaerobic digestion.

Total installed costs that US residential consumers pay for solar PV have also been falling fast, from nearly \$7 per watt of peak system capacity in 2008 to less than \$4 in 2013. We think that could be as little as \$1.60 by 2020. The bottom line: cleantech is getting more economically competitive.

## **Myth 3: The sector depends on regulatory support**

Four critical elements—cost, access to capital, the go-to-market approach (broadly defined),<sup>4</sup> and regulation—typically must come together to create successful cleantech businesses.

As the industry matures, the relative importance of these factors is changing: regulation is becoming irrelevant in many cases as clean technologies find their competitive footing. LED lighting is one example: in 2013, LED light sources accounted for the majority of the sales of several large lighting manufacturers, even in markets where incandescent bulbs are still widely available. That figure could rise to more than 80 percent by 2015.

Solar provides evidence both for and against the need for continued regulation. Given budget concerns, a number of countries have canceled or reduced subsidies, and growth has slowed. But the larger point is that solar is still growing. For example, Germany has cut its feed-in tariffs to encourage renewables production, and its strategy of *Energiewende*—a long-term effort to deploy renewables, move away from fossil fuels, and phase out nuclear power—has had some troubles. But the use of renewables continues to grow. Globally, solar installations have risen by 57 percent a year, on average, since 2006. One lesson is that sudden changes in regulation can create peaks and valleys in demand, and that isn't helpful to establish an industry on a sound footing. But the point is that while regulation can be and has been helpful to launch clean technologies, it is no longer critical in many sectors.

The reason isn't only that these technologies continue to advance, although that is the case. What's more interesting is the increased sophistication of business models, financing, and management practices. There are, for example, significant innovations in how

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<sup>4</sup> The broad go-to-market approaches encompass the wide range of activities (such as marketing, sales, distribution, pricing, and channel management) needed to get products and services to customers and also include the business models companies use, partnerships with established players, and the set of product offerings available.



cleantech companies are getting access to lower-cost sources of capital, such as cleantech bonds and third-party financing.

And business-model innovations are all over the cleantech map. Water-treatment companies are creating leasing options that reduce capital outlays for filtration technology to encourage its faster deployment. Car-sharing services save millions of tons of carbon in Europe and the United States by making auto ownership more efficient. There are initiatives to use waste products from one industry as feedstock for another; some brewers, for example, are using spent grain as a fuel source for their steam boilers. So far, every company involved has reported increased profits and decreased carbon emissions. A whole new industry has been created around using IT to reduce energy consumption. Some companies, such as C3 Energy, sell electric utilities software as a service, which analyzes the data generated across their electrical networks to help improve grid operations and asset utilization, thereby increasing profits. Green businesses, in short, are benefiting from better, more creative management practices.

## Partnerships and progress

The big guns are taking note. For example, there are power-train partnerships, like Daimler and Tesla's, between the biggest global car giants and small but rapidly growing electric-car companies. The US Department of Defense is working with renewable producers on off-site energy production, and the European oil major Total has taken a controlling investment in SunPower. Such partnerships should help get offerings to market much faster, while giving the smaller firms access to lower-cost capital.

Advanced building technologies, having proved their economic worth and utility, are proliferating—and they are standard for new construction in some markets. So are smart water sensors. The

price and energy requirements of water-treatment technologies have fallen, and investment is strong. Smart-grid hardware has been deployed widely in the past decade, and as users figure out how to use big data and analytic tools, it will become much more important, as witnessed by Google's recent acquisition of Nest Labs for \$3.2 billion. For the first time, next-generation vehicles show signs of becoming this-generation vehicles.

We are witnessing the maturation of an industry and the adoption of proven management practices. Successful cleantech companies are making their offerings competitive by focusing on excellence in operations, marketing, sales, and distribution. The principles that apply to any manufacturing business, such as reducing procurement costs and improving productivity through lean manufacturing, are increasingly important for clean technologies as well. The same can be said for practices such as customer segmentation, channel access, and pricing. As these businesses continue to scale up, there will be additional opportunities for improvement.

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Trends can accelerate, slow down, or even reverse. But it's unlikely that all these technologies will fail, and many are now at the stage where management practices, and not regulation or subsidies, are the defining factor for success. Those that do succeed could be highly disruptive to incumbents, even (or especially) entrenched ones. Big changes in resource use and business models are just around the corner.

To be sure, some cleantech companies will go bust, and some technologies will not make the cut. But these ups and downs are simply the nature of business—part of progress. Notwithstanding the failures of individual companies, cleantech is not going away, either on the ground or as an investment opportunity. And that's no myth.

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# Recently on McKinsey.com

**112**

Biodiversity: The next frontier in sustainable fashion

**120**

Ørsted's renewable-energy transformation

**126**

How airlines can chart a path to zero-carbon flying

**136**

Climate risk and decarbonization: What every mining CEO needs to know

**148**

Charging electric-vehicle fleets: How to seize the emerging opportunity



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# Biodiversity: The next frontier in sustainable fashion

It's time for the apparel industry to radically reduce the industry's contribution to biodiversity loss. Here are four interventions that can make the biggest impact.

*by Anna Granskog, Franck Laizet, Miriam Lobis, and Corinne Sawers*

**Even amid the COVID-19 pandemic**, sustainability remains top of mind for consumers, investors, and regulators—in fact, engagement in sustainability has deepened during the crisis. For example, two-thirds of apparel shoppers say that limiting impact on climate change is now more important to them since before COVID-19.<sup>1</sup>

But while much has been written about the fashion industry's impact on climate change, less well known and well covered is the industry's heavy footprint on biodiversity. Broadly defined as the variety of all life forms on earth, biodiversity matters. We rely on it for food and energy, and we depend on its irreplaceable role in sustaining air quality, providing fresh water and soil, and regulating climate. And yet biodiversity is declining at a faster rate than ever before in human history.<sup>2</sup> One million species, between 12 percent and 20 percent of estimated total species, marine and terrestrial alike, are under threat of extinction.

The apparel industry is a significant contributor to biodiversity loss. Apparel supply chains are directly linked to soil degradation, conversion of natural ecosystems, and waterway pollution.

This article examines the apparel industry's largest contributors to biodiversity loss, how companies can strategically mitigate that loss, and what brands can do to boldly lead the industry's biodiversity efforts.

## **Apparel's contribution to biodiversity loss**

For several years now, apparel companies have been active in the fight against climate change, launching myriad initiatives to become carbon neutral. Biodiversity is a distinct but related issue. Biodiversity loss and climate change are interdependent and mutually reinforcing—one accelerates the other, and vice versa. For example, protecting forests could help reduce greenhouse-gas emissions. In turn, the rise of global temperatures increases the risk of species extinction.

Because biodiversity is such a complex and multidimensional landscape, and ecosystem degradation is so wide ranging—affecting oceans, freshwater, soil, and forests—multiple metrics and indicators are needed to measure impact and progress. Setting targets and accountability for such a complex range is much more challenging than managing for the single metric of greenhouse emissions.

Through our analysis of quantitative impact indicators as well as industry-expert interviews, we have developed a good understanding of how each part of the apparel value chain affects biodiversity. Most of the negative impact comes from three stages in the value chain: raw-material production, material preparation and processing, and end of life (Exhibit 1).

We also have developed a map of biodiversity impact areas to help companies determine where to focus their efforts (Exhibit 2).

Based on our analysis, we have identified the apparel sector's five largest contributors to biodiversity loss. They are presented according to the fashion value chain, not by magnitude of impact:

- **Cotton agriculture.** Cotton is the most used nonsynthetic fiber in the world. Farming it is especially insecticide and pesticide intensive: although cotton grows on only 2.4 percent of global cropland, it accounts for 22.5 percent of the world's insecticide use—more than any other single crop—and 10 percent of all pesticide use. Cotton is also a water-intensive crop; some estimates suggest that 713 gallons (2,700 liters) of water are needed to produce one T-shirt.<sup>3</sup>
- **Wood-based natural fibers/man-made cellulose fibers (MMCFs).** MMCFs are created from cellulose, mainly derived from wood. According to estimates, more than 150 million trees are logged annually for MMCFs.<sup>4</sup> While the majority of MMCFs come from tree plantations

<sup>1</sup> "Consumer sentiment on sustainability and fashion in the COVID crisis," May 2020, McKinsey.com.

<sup>2</sup> *IPBES 2019 Global assessment report on biodiversity and ecosystem services*, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, May 2019, ipbes.net.

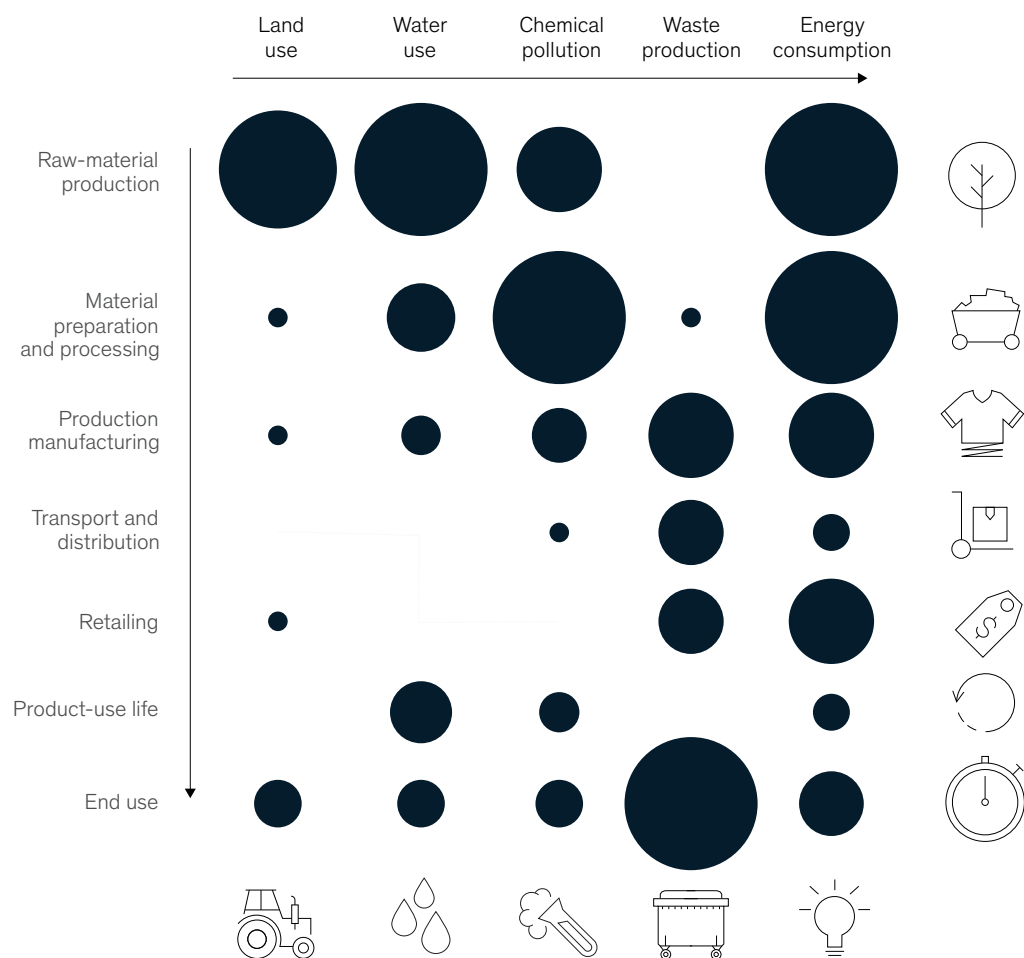
<sup>3</sup> *Handle with Care: Understanding the hidden environmental costs of cotton*, "World Wildlife Magazine," Spring 2014, worldwildlife.org.

<sup>4</sup> *CanopyStyle*, "Canopy, 2020, canopyplanet.org.

Exhibit 1

## Most of the negative impact on biodiversity comes from raw-material production, material preparation and processing, and end of life.

Relative impact on biodiversity along the apparel value chain, larger circle = higher negative impact



<sup>1</sup>Includes yarn preparation, fabric preparation (weaving and knitting), and dyeing.

<sup>2</sup>Includes cut, make, and trim (CMT) and washing and finishing.

Source: Expert interviews; McKinsey analysis

that are certified and sustainable, up to 30 percent of MMCFs may come from endangered and primary forests.<sup>5</sup> Furthermore, water and soil pollution from chemicals used in plantation forests and during pulp processing drive habitat loss and endanger species, unless the process is 100 percent closed loop.

— **Textile dyeing and treatment.** Approximately 25 percent of industrial water pollution comes from textile dyeing and treatment. These processes overexploit freshwater resources and contaminate waterways through chemical runoff and nonbiodegradable liquid waste. Of the 1,900 chemicals used in clothing production,

<sup>5</sup>D.G. McCullough, "Deforestation for fashion: Getting unsustainable fabrics out of the closet," *Guardian*, April 25, 2014, theguardian.com.







## Exhibit 2

### A map of biodiversity impact areas can help companies determine where to focus their efforts.

Apparel value-chain pressure on biodiversity,<sup>1</sup> (not exhaustive)  
impact areas, and assessment of impact level

High impact ■■■ Low impact ■■■

	Land and water	Pollution	Climate change <sup>2</sup>	Overexploitation <sup>3</sup>
Raw-material production for natural and synthetic fibers 	<b>Cotton agriculture</b> Soil degradation from excessive water use and habitat loss from area expansion	<b>Cotton agriculture</b> Chemically intensive crop production		
	<b>Wood-based natural fibers</b> Deforestation and biodiversity loss through monocultures	<b>Wood-based natural fibers</b> Agrochemicals used in plantation forests and pollutants discharged by pulp mills	<b>Greenhouse gas</b> Emissions from deforestation and pulp production	<b>Monocultures for tree-based natural fibers</b> Replace natural forest and threaten native biodiversity
	<b>Livestock breeding</b> Deforestation due to land use for grazing and feed grain production	<b>Livestock breeding</b> Water pollution from animal waste, antibiotics/hormones, fertilizers, etc.		<b>Livestock breeding</b> Proliferation in the wild of species used in fur farms (mink, possum, raccoon)
	<b>Natural fibers from wild animals</b> Disruption of food chains and trapping of nontarget species			<b>Natural fibers from wild animals</b> Over-exploitation of certain species for their skins, fur, and wool (vicuña)
	<b>Synthetic fibers</b> Destruction of natural habitats for mining of coal and petroleum for polyester	<b>Synthetic fibers</b> Antimony-contaminated wastewater from production	<b>Energy use</b> For synthetic-fiber production	
	Land and water	Pollution	Climate change <sup>2</sup>	Overexploitation <sup>3</sup>
Material preparation, processing, and product manufacturing 		<b>Textile dyeing and treatment</b> Freshwater contamination through chemical runoff and non-biodegradable waste	<b>Energy use</b> For fabric preparation, dyeing, and washing	
		<b>Leather tanning</b> Air, ground, and water pollution from chemicals and toxins		
Transport and distribution 			<b>Transport mode</b> Emissions from air, sea, road, or rail freight	<b>Spread of alien species</b> Existing species endangered by imported alien species
	<b>Waste disposal by landfill</b> Habitat loss for use as landfills	<b>Washing</b> Waterway pollution from microfibers		
Retailing, product use, and end of life 		<b>Pollutants</b> From landfills, incineration, and leakage into waterways		

<sup>1</sup>Habitat loss, degradation, and fragmentation.

<sup>2</sup>As climate is already widely researched, we've taken it out of scope.

<sup>3</sup>Overexploitation of biological resources and invasive alien species.

Source: D. Aiama et al, *Biodiversity risks and opportunities in the apparel sector*, International Union for Conservation of Nature, 2016, portals.iucn.org.



the European Union classifies 165 as hazardous to the health or the environment.<sup>6</sup>

- **Microplastics.** An average of 700,000 fibers is released in a standard laundry load,<sup>7</sup> and half a million tons of microfibers (which are a type of microplastic) end up in oceans every year.<sup>8</sup> An estimated 35 percent of primary microplastics in the world's oceans originate from the washing of synthetic textiles.<sup>9</sup> Toxic chemicals in synthetic microfibers poison marine wildlife.
- **Waste.** Only 12 percent of textile waste is downcycled (broken down into its component materials), and less than one percent is closed loop recycled. Nearly three-fourths—73 percent—of textile waste is incinerated or ends up in landfills, which release pollutants into their surroundings and contribute to habitat loss.<sup>10</sup> Anywhere from 30 to 300 species per hectare may be lost during the development of just one landfill site.<sup>11</sup>

These are sobering statistics. For the apparel sector to slow broader global biodiversity loss, a radical shift from business as usual will be necessary.

#### Four intervention areas to focus on

The good news is that apparel companies have started to pay attention to this issue—and have the power to truly move the needle. While apparel companies can take numerous potential actions

that could be relevant and synergistic, each action will come with trade-offs. Based on our analysis, apparel companies would do well to prioritize the following high-impact strategic interventions:

#### 1. Scale up innovative materials and processes

There is no perfect material. As discussed, each of the most commonly used materials in the apparel industry—cotton, MMCFs, and synthetics—has a negative impact on biodiversity. But each of these can be made more sustainable. Furthermore, better alternatives do exist and could dramatically improve with more investment and innovation.

#### Improve the sustainability of cotton, MMCFs, and synthetics

The agricultural techniques used to produce raw materials have a significant effect on biodiversity.

Multiple technologies that are already available today—precision agriculture, integrated pest management (IPM), and micro-irrigation—reduce water and chemical intensity to a certain extent.<sup>12</sup>

A broader shift that includes organic and even regenerative agriculture has the potential to go further. But as we mentioned earlier, there are trade-offs.

Organic cultivation restricts the use of fertilizers and crop-protection chemistries. It's also, depending on the location, been shown to use up to 90 percent less blue water (the rainfall that enters bodies of water, the main source of water used for irrigation

## Apparel supply chains are directly linked to soil degradation, conversion of natural ecosystems, and waterway pollution.

<sup>6</sup> *Environmental impact of the textile and clothing industry*, European Parliamentary Research Service, January 2019, [europarl.europa.eu](http://europarl.europa.eu).

<sup>7</sup> Ocean Clean Wash, 2019, [oceancleanwash.org](http://oceancleanwash.org).

<sup>8</sup> *The new plastics economy: Rethinking the future of plastics & catalysing action*, Ellen MacArthur Foundation, December 13, 2017.

<sup>9</sup> Julian Boucher and Damien Friot, *Primary microplastics in the oceans*, International Union for Conservation of Nature, 2017, [iucn.org](http://iucn.org).

<sup>10</sup> "One garbage truck of textiles wasted every second: Report creates vision for change," Ellen MacArthur Foundation, November 28, 2017.

<sup>11</sup> *The effects of landfills on the environment*, Sciencing, April 19, 2018, [sciencing.com](http://sciencing.com).

<sup>12</sup> Aavudai Anandhi and Narayanan Kannan, *Water management for sustainable food production*, MDPI, March 11, 2020, [mdpi.com](http://mdpi.com).

purposes).<sup>13</sup> Regenerative techniques—both organic and nonorganic—have shown the potential to restore soil micronutrients over time.

Organic-cotton production is unlikely to be realizable at scale and achieve the efficiency of conventional systems.<sup>14</sup> Currently, its market share is just one percent of the total cotton market.<sup>15</sup> It typically yields 15 to 25 percent lower harvests and has more volatility during the production cycle. What's more, converting agriculture production systems to organic is challenging, especially for small-scale farms, as the conversion process can take up to three years.

To find a scalable solution, the apparel industry needs to consider how to optimize global cotton production's environmental footprint. That will require supporting multiple production systems that balance efficiency, environmental stewardship, and farmer needs, which together must also meet the demands of the end customers.

As for MMCFs, many brands are already sourcing them from plantations certified by the Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC). And as for synthetics, some brands are reducing their use of fossil-fuel-based synthetics in favor of sustainably sourced natural fibers, recycled PET,<sup>16</sup> or biobased synthetics. These alternatives do, however, have limitations. For one, biobased synthetics break down into acid in water, contributing to ocean acidification. Recycled fibers are technically complex to produce. And because MMCFs and synthetics are by-products of other industries (such as the paper and pulp industry or the oil industry), apparel companies have less influence over how these materials are produced.

### **Invest in textile innovation**

R&D into material innovation has yielded numerous lower-impact alternatives to conventional fibers. Lyocell, a cellulose fiber made from gum trees, and

Spinnova, made from wood pulp and agricultural waste, leverage closed-loop or zero-percent-chemical approaches. Biodegradable polyesters and biopolyesters are made from nonsynthetic natural materials like starch or cellulose. Recycled fibers not only repurpose waste but also have a lower biodiversity footprint than virgin fibers.

Scaling up the commercial availability of these innovative fibers will require investment. Economies of scale should help reduce price points, but these newer materials are likely to remain expensive, used only by sustainability-minded designers. As for recycled fibers, scaling will depend on whether they can be made more robust and less prone to shedding so that they don't contribute to microplastic pollution, and on whether recycling blend textiles becomes viable.

## **2. Take an aggressive stance against waterway pollution**

In the absence of effective regulation, waterway pollution from textile dyeing and processing requires a tougher stance from apparel brands.

Because many suppliers in developing countries lack the resources and knowledge to monitor and track the chemicals they use, brands need to step up and engage with suppliers through education, targeted investment, and stricter accountability to establish basic certification standards at scale. At the very minimum, suppliers should comply with Zero Discharge of Hazardous Chemicals, Manufacturing Restricted Substances List (ZDHC MRSL), and Wastewater Guidelines, which regulate the use of hazardous chemicals and wastewater discharge.

Once standards are in place, brands and suppliers can pursue more high-tech options to reduce nonbiodegradable waste. These include moving from wet processing to waterless dyeing, which uses supercritical carbon dioxide, or to digital printing, which reduces water and chemical

<sup>13</sup> Textile Exchange, 2019, [textileexchange.org](https://textileexchange.org).

<sup>14</sup> Dionys Forster et al, "Yield and economic performance of organic and conventional cotton-based farming—results from a field trial in India," *Plos One*, December 4, 2013, [journals.plos.org](https://journals.plos.org).

<sup>15</sup> *2025 Sustainable Cotton Challenge*, first annual report, Textile Exchange, 2018, [textileexchange.org](https://textileexchange.org).

<sup>16</sup> Polyethylene terephthalate.

dependency. For example, Netherlands-based DyeCoo's waterless dyeing technology saves 32 million liters of water and 160 tons of processing chemicals a year.<sup>17</sup> Advanced wastewater-treatment technologies, such as purifying water through reverse osmosis, are also highly effective, with a recovery rate around 90 percent and the ability to reuse treated wastewater in a closed-loop system.<sup>18</sup> In addition, apparel companies can switch to "greener" chemicals (such as plant-based instead of mineral-oil-based lubricants) or natural dyes, which generate less effluent.

Most of these technologies are well established. The key hurdle is higher cost. For example, DyeCoo's waterless dyeing machine runs from \$2.5 million to \$4 million. Apparel brands need to consider how to work with suppliers and potentially local governments to finance long-term investments in cleaner technologies.

### 3. Lead the way in education and empowering consumers

Brands can help further educate consumers about what they can do to minimize the impact of their actions on biodiversity loss. Simple behavioral adjustments and consumption choices can have substantive results. For example, just doing laundry differently—specifically, in the following three ways—can make a big impact.

- **Washing in cold water.** Laundering synthetic garments releases microplastics into the water system; the more water used, the more friction happens between clothes and the more microplastics are shed. Changing washing-machine settings from delicate to cold express cycles can reduce microfiber shedding by 57 percent.<sup>19</sup>
- **Filtering microfibers.** Consumers can retrofit microfiber filters into their washing machines to prevent microfibers from entering waterways. An even lower-cost solution is to

use fiber-collection bags, which are essentially specialized laundry bags that can catch 90 to 99 percent of microfibers before they enter water systems.

- **Using water-efficient washing machines.**

Consumers can also pay attention to water efficiency when purchasing a washing machine. On the commercial side, waterless—and nearly waterless—washing machines can save up to 80 percent of water used by traditional machines, plus they limit microplastics shedding.

Another way consumers can have a disproportionately positive impact on biodiversity is to get more use out of clothes they already own. Using a piece of clothing nine months longer can reduce its associated CO<sub>2</sub> emissions by 27 percent, its water use by 33 percent, and its waste by 22 percent.<sup>20</sup>

In addition, consumers can reduce waste through garment repair, recycling, and resale. Prominent campaigns by retailers like H&M, which accepts any brand's clothing for recycling, are gaining traction. Brands have extraordinary influence to market such initiatives, ensure they have consumer appeal, and shift consumer mindsets and behaviors.

Besides helping drive consumer awareness, brands can incentivize behavioral change—for example, by offering small vouchers in exchange for used clothing. The industry can further push by providing viable business models for repair and reuse like Patagonia did in 2019, when its Worn Wear Program repaired more than 40,000 pieces of clothing.

### 4. Relentlessly pursue zero waste

One of the most powerful changes the apparel sector can make in the interest of biodiversity is to simply stop making too many clothes. Average overproduction is estimated around 20 percent. Manufacturers recycle roughly 75 percent of preconsumer textile waste. But the remaining

<sup>17</sup> BusinessEurope, 2019, [business-europe.eu](https://business-europe.eu).

<sup>18</sup> Peter Hauser, *Advances in Treating Textile Effluent*, paragraph 2.1.6.1, first edition, Rijeka, Croatia: InTechOpen, 2011.

<sup>19</sup> Max R. Kelly et al, "Importance of water-volume on the release of microplastic fibers from laundry," *Environmental Science and Technology*, Volume 52, Number 20, August 28, 2019.

<sup>20</sup> *Valuing our clothes—The true cost of how we design, use and dispose of clothing in the UK*, WRAP, 2012, [wrap.org.uk](https://www.wrap.org.uk).

25 percent primarily ends up in landfills or is incinerated—without ever having been worn, though some of it may be donated.

## Demonstrate bold leadership

The general steps that apparel companies can take to help transform sustainability in the industry are well known. But if the industry is to make measurable, significant progress on biodiversity specifically, companies must demonstrate leadership in the following ways:

- ***Manage for biodiversity like you manage value creation.*** Factor biodiversity impact into financial reporting—for example, through impact-weighted accounts or environmental profit-and-loss approaches—and manage it like financial performance. Commit to forthcoming biodiversity science-based targets to further channel internal sustainability-related investments.
- ***Shift the paradigm on supplier engagement.*** Upstream biodiversity interventions are complex and can often have associated costs. Collaborate with other brands to define joint standards for suppliers. The suppliers will benefit from less operational complexity and economies of scale, while brands can push for more stringent specifications rather than dilute them to the lowest common denominator.
- ***Invest in the broader ecosystem to accelerate and scale innovation.*** Team up with other apparel companies to invest in scaling

and industrializing emerging, low-impact technologies and substitutes for nonsynthetic fibers. With a multitude of viable options on the market, the priority should be on focusing investments to establish new dominant materials and processes.

- ***Push for change in adjacent, relevant industries.*** The apparel sector is closely intertwined with the agricultural, livestock, and chemical industries; all face similar challenges in addressing their biodiversity footprints. Pushing for closer cross-industry collaboration through working groups and roundtables will be mutually beneficial to all participants.
- ***Engage with policy makers and welcome regulations.*** Be proactive in engaging on meaningful biodiversity regulation. Existing regulations such as the EU Single-Use Plastics Directive or Extended Producer Responsibility schemes (for product disposal/recycling) have helped make sustainability a shared responsibility.

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We expect biodiversity to become an even greater concern for consumers and investors in the coming years. COVID-19, instead of slowing the trend, has accelerated it—perhaps because people now understand more deeply that human and animal ecosystems are interdependent. It's time for the apparel industry, which to date has contributed heavily to biodiversity loss, to now make bold moves in the opposite direction.

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## Ørsted's renewable-energy transformation

Twelve years ago, the Danish energy company made most of its money from fossil fuels. Today, it's the world's leading offshore-wind power producer. The head of Ørsted's offshore-wind business tells the story of this change.



**To stop climate change**, companies in every industry must rapidly reduce their carbon emissions. That is no easy task, but a few businesses show it can be done. Ørsted, an energy company based in Denmark, stands out as an example. Twelve years ago, when it was called DONG Energy, the company earned most of its revenues by selling heat and power, 85 percent of which came from coal. Then, in 2009, management announced a major strategic shift: the company would seek to generate 85 percent of heat and power from renewable sources by 2040.

Ørsted invested aggressively in offshore wind and phased out coal. By 2019, it had become the world's largest producer of offshore-wind energy. The company also raised its renewable-generation share to 86 percent—hitting its target 21 years ahead of schedule. In an interview with McKinsey, the CEO of Ørsted's offshore-wind business, Martin Neubert, tells the story of the company's transformation: the strategic decision that started it all, the changes it went through, and the outlook for the future. (The remarks below have been condensed and edited for clarity.)

**McKinsey:** *Back in 2008, DONG Energy was a profitable and stable conventional-energy company. How did the idea of pivoting to renewables come up?*

**Martin Neubert:** At that time, DONG Energy was largely a domestic Danish energy company. Eighty-five percent of our power and heat production was powered by coal, and 15 percent by renewables. For us, one key factor supporting the decision to rethink our strategy in favor of renewables was the failed attempt to develop a 1,600-megawatt coal-fired power plant project, called Lubmin, in Northeast Germany.

We had made substantial investments in this greenfield project during the more than six years we spent trying to develop it. And while the project was supported by the German federal government, we experienced strong local opposition against the idea of building a coal-fired power plant on the Mecklenburg-Vorpommern coastline. This was the first clear sign telling us that the world was beginning to move in a different direction, and we concluded that there was no sustainable way of realizing the project. Also, in 2009, the global renewable-energy agenda was positioned strongly at the United Nations COP15 [15th Conference of the Parties] climate summit in Copenhagen, supported both by the Danish government and by our board of directors.

**McKinsey:** *How did management assess the company's position and its ability to shift toward renewables?*

**Martin Neubert:** In 2008–09, we formulated a new strategy and vision called 85/15, stating that we wanted to change our generation mix from 85 percent conventional, 15 percent renewable to 85 percent renewable, 15 percent conventional. The 85/15 split, which was decided on by executive management, reflected the ambition to conduct a complete turnaround of our generation mix. It also took into account that DONG Energy had spent three decades establishing itself as a company focused on the generation of conventional fuels. So the expectation was that such a turnaround would have to be completed within one generation, or the equivalent of 30 years.

At the time, I don't think anyone thought we would turn our generation mix upside down within only ten years. But that was not the discussion then. Instead,



# Ørsted raised its renewable-generation share to 86 percent—hitting its target 21 years ahead of schedule.

we discussed what our future growth areas should be: areas where we had critical mass, where we had the right competences, and where we could differentiate ourselves. It became clear that one was wind power, which three of the six companies that merged to become DONG Energy in 2006 had already pursued.

Onshore wind was well established. We had a sizeable portfolio of projects in Poland and Sweden, and we had been involved in projects in Spain and Greece. As for offshore wind, we had early-stage operating projects in Denmark and the United Kingdom and large-scale development projects. That gave us critical mass in wind when we formulated our vision.

We also had a team of 50 or 60 people working on renewable-energy projects. Some had spent their careers on these technologies, particularly onshore wind. That gave us substantial in-house expertise, backed by a clear understanding of what it would take to develop wind power, technology-wise.

**McKinsey:** *Back then, the technology landscape for offshore wind looked very different from what it looks like now. How did that factor into your thinking?*

**Martin Neubert:** At the time, no offshore-wind projects bigger than 160 megawatts had been built. So we had to ask how we could build large-

scale offshore-wind projects in a different way. Could we move from building one highly customized offshore-wind project every two or three years to building one or two more standardized projects every year? What would it take to go from handcrafting to serial production?

Answering that question involved a 360-degree review: the supply chain, our competencies, the financing models. We concluded that we could not do it alone. One challenge was installation. The installation companies in the market were small. We found a considerable risk that they could go bankrupt during a project. That led us to acquire A2SEA as an installation supplier.

We would also need strong partnerships with suppliers of turbines, foundations, and cables. Turbines were a particular issue. Since no purpose-built installation vessels existed, we reasoned that we would benefit from working with a manufacturer on the design, layout, and funding of second-generation installation vessels. Siemens quickly realized that offshore wind could develop into a large industry. We entered a partnership with them, which included the delivery of 500 3.6-megawatt turbines. At the time, it was one of the largest energy agreements Siemens had ever made.

**McKinsey:** *How did executives and staff react to the decision to take the company in a new direction?*

**Martin Neubert:** There was internal pressure to keep DONG Energy the same. It wasn't unexpected, because we had spent three decades turning the company into a traditional fossil-fuel company. Fossil fuels were our core competence and the focus of our growth strategy. Our employees also perceived that we were the world's best at running coal-fired power plants, and a benchmark for the industry. The skepticism was broad and profound.

Ultimately, though, internal skepticism receded. In 2012, when Henrik Poulsen had just joined as CEO, our portfolio of assets and activities had high exposure to gas and gas-fired power plants. As gas prices dropped in the United States, vast amounts of surplus American coal ended up in Europe, where it replaced gas as the preferred fuel for power generation. That caused us financial difficulties, which made it easier for people to accept the new focus on offshore wind and on the exploration and production of oil and gas, and the moves to divest noncore businesses.

We began implementing the new strategy by establishing a wind-power business unit. I think those of us who were asked to join this business unit saw it as the beginning of an interesting journey. A group of strong European utilities was active in UK offshore wind at the time. We all thought that something big was going on and that the UK would be the right place to pursue offshore-wind projects at industrial scale.

That proved to be the case when the UK government strengthened its support for offshore wind to help make these projects financially viable. If that hadn't happened, I'm not sure that we would have progressed as fast as we did.

**McKinsey:** *Getting into offshore wind required a multiyear effort to sell holdings and build up new assets. How did management secure the necessary*

*capital even as the company was exiting businesses that were reliable sources of cash?*

**Martin Neubert:** We had multiple new projects in the UK that needed funding. One model would have involved financing them with external debt and then divesting once the projects were operational. But raising debt for each project would not have worked well with our group-level funding strategy. Another approach, partnering with electric utilities, would have been too complicated, because these companies had their own asset portfolios and strategies.

We needed financial partners that could deliver capital and manage their investments while relying upon our experience constructing and operating offshore-wind projects. One structural issue, however, was that we did not want to use project financing, whereas many of our financial investors preferred or were even required to leverage their investment via project financing.

This led us to develop the "farm down" model, in which we could fund our half of a project on our balance sheet and partners could use project financing to fund the rest. With farm-downs happening before commissioning, we provided investors with turnkey project offerings, which would protect them from risks we can manage best, including development, construction, and operating risks. That model resonated with the Danish pension funds, and later with Dutch and Canadian pension funds and other investors.

Had we not developed the farm-down model, we couldn't have funded all these projects in Europe. And the structure that we innovated became widely used in the industry.

**McKinsey:** *What organizational changes took place as Ørsted's portfolio shifted toward renewables?*

**Martin Neubert:** By 2012, our wind-power business unit had grown to hundreds of employees. But it was still working like a start-up. To support new projects, we added whatever resources were needed, which led to inefficiencies. We lacked a proper organizational structure and operating model.

Correcting that was one of the key accomplishments of my predecessor, Samuel Leupold. He introduced our first real operating model, establishing global functions, clear project governance, and a product-line organization that systematically reduced the cost of offshore-wind electricity by eliminating ad hoc or project-specific sourcing and procurement.

During the past three years, Ørsted has also cultivated a “one company” approach spanning our business units. For example, we have established a management-team forum, consisting of all EVPs and SVPs, who meet four times a year to talk about our strategy and strategic enablers such as talent and digital. That forum facilitates open discussions to break silos, align our approach, and build a strong network among senior leaders. In addition, we have reestablished our leadership-forum meetings for our top 400 leaders.

**McKinsey:** *Ørsted has made significant moves in recent years. Can you talk about those, and the rationale for them?*

**Martin Neubert:** The strategic steps we’ve taken during the past three to five years have focused on turning Ørsted into a global renewable-energy major. The first step was divesting our oil and gas business, which concentrated our business almost entirely on renewables. We also invested in the conversion of our domestic heat and power plants, enabling them to move away from coal toward

biomass. As a result, we will exit coal in 2023, and our power generation will be carbon neutral in 2025.

In 2016, we completed our IPO, and DONG Energy, which we were still called at the time, became a publicly listed company. The IPO provided us with the flexibility and access to equity that we need to fund growth. The IPO also gave institutional and retail investors an opportunity to take part in our green transition, while sharpening our profile as a renewable pure-play.

Within the past couple of years, we have reentered the onshore-wind market and moved into solar PV [photovoltaic] and storage solutions. These moves will help diversify our technology mix so we can better meet the demands of our customers. What’s important to note is that we are moving into these technologies at scale. North America, for example, is a large market for onshore wind and storage solutions, and we are investing there. Everything we do reflects our vision to create a world that runs entirely on green energy. And while offshore wind has the potential to power the world, we’re convinced that a broader technology mix will support the growth of our company even better.

**McKinsey:** *Ørsted’s transformation into an offshore-wind leader has been complete for some time. What opportunities do you see for growth in that market?*

**Martin Neubert:** Our ambition is to remain the global leader in offshore wind. In the past two to three years, offshore wind has expanded from a predominantly European market to a global market. We’ve been a first mover as that shift has occurred. We were the first European developer that went into large-scale offshore wind in the US. We were

also the first foreign offshore-wind developer to enter Taiwan. Within a few years, we have developed sizable project portfolios in both markets.

To support our growth, we recently reorganized our offshore-wind business and established four new regions. Moving closer to different markets is important for navigating their development. It also helps with commercial matters like owning wind farms. At the same time, we want to keep the scale advantages, leverage, and standards that our global operations and EPC [engineering, procurement, construction] functions deliver, and so they work closely with our regions.

**McKinsey:** *New horizons for change in the energy sector are coming into view. How does management keep working hard to ensure that Ørsted remains a leader in offshore wind, while challenging itself to gain a strong position in the energy industry's next evolutionary phase?*

**Martin Neubert:** We ask ourselves that regularly. And I have been asked many times, by investors, by the media, and by people within our organization, if we are at risk, considering that bottom-fixed offshore wind is our bread and butter. We value our global leadership position in offshore wind, and we want to retain that. Obviously, we don't want to miss out on major developments—for example, in floating offshore wind. But we must respond as the needs of our customers change.

The ability to reinvent ourselves has proven to be key. In 2006, DONG Energy consisted of some oil and gas licenses. Then it reinvented itself through the merger of six domestic energy companies. A few years later, the company reinvented itself again by establishing a wind-power business unit that became a global leader within a few years. Scanning new horizons and spotting new business areas are essential to Ørsted's strategy and our ambition to become a global renewable-energy major.

**Martin Neubert** is executive vice president and CEO of offshore wind at Ørsted. This interview was conducted by **Christer Tryggstad**, a senior partner in McKinsey's Oslo office.

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# How airlines can chart a path to zero-carbon flying

The coronavirus crisis will transform aviation, giving airlines their best chance yet to address climate change. Sustainable fuels are a key part of that strategy.

*by Alex Dichter, Kimberly Henderson, Robin Riedel, and Daniel Riefer*

**The airline industry** is understandably focused on the coronavirus pandemic's impact on growth, along with the health and livelihoods of its millions of workers.

This year now represents the biggest retrenchment in the history of aviation, with airline capacity down roughly 75 percent as of early April. That means an industry with a predictably steady growth rate has suddenly shrunk to a fraction of its size. It is unclear how protracted the decline will be, though demand is likely to bottom out in 2020 before returning to pre-crisis levels several years from now. The timing will depend on many factors outside the industry's control.

In the longer term, aviation is likely to undergo structural changes with regard to demand and the degree of industry consolidation, along with unprecedented government support. That transition provides an opportunity to rebuild the industry for a low-carbon future, something that airlines have been grappling with for some time.

Even before the coronavirus pandemic began, the industry was facing the challenge of reducing its carbon emissions in line with international goals to reach net-zero emissions by 2050. Forces that have buoyed the case for sustainability—including customers and regulators worried about emissions and unpredictable future carbon policies—have shifted with the pandemic, as airlines' survival seems to be at stake.

The industry has a solid record on fuel efficiency: fuel burn per passenger-kilometer has dropped by half since 1990, according to the International Air Transport Association. The current crisis could provide forward-thinking airlines with a chance to emphasize their fuel-efficiency programs and justify the retirement of older, less-fuel-efficient aircraft (see sidebar, "Ten questions airline executives should be asking"). Modernizing fleets and improving operational efficiency are important; however, in the best case, annual industry growth

counters the emissions that they save. Carbon offsetting holds more promise, and it can help serve as a bridge while the industry takes action needed to reduce its own emissions over time.

The option that could be transformative, aligning the industry's growth ambitions with Paris Agreement targets, is sustainable aviation fuel (SAF). Compared with fossil kerosene, SAF could mean a reduction in carbon emissions of 70 percent to almost 100 percent. While SAF has drawbacks, including high prices and supply concerns, airline CEOs should view it as a promising tool in their decarbonization toolkits. To help push options forward, airlines can make targeted investments and purchase commitments that would increase SAF use (currently at less than 1 percent of total consumed jet fuel) while reducing costs.

Because of the scale of the challenge, any solution will require a multistakeholder approach that also includes governments, tech players, and suppliers. The trick is to create a suitable regulatory framework and supporting incentives so that no single player is penalized for going it alone.

## **The case for action**

The aviation industry has taken steps to address rising emissions. In 2009, it set ambitious targets that include carbon-neutral growth from 2020 onward and halving its net emissions from 2005 levels by 2050.

We don't know what the pandemic will mean for emissions growth over time. But the target for all industries, companies, and countries is to reach net-zero carbon emissions by 2050, as laid out in the Intergovernmental Panel on Climate Change goals of limiting global warming to no more than 1.5°C above preindustrial levels. As the energy and transportation industries create a path to decarbonize, sectors in which climate effects are hard to abate are coming under more pressure, and aviation is no exception. McKinsey recently developed a set of



1.5°C scenarios that would see reductions in aviation emissions of 18 to 35 percent compared with a business-as-usual pathway by 2030.<sup>1</sup>

Nations excluded aviation and international shipping when setting carbon targets because emissions are difficult to allocate to a particular country. But airlines shouldn't risk the perception that they aren't doing enough about CO<sub>2</sub>, especially amid mounting scrutiny from the flying public, the media, investors, and regulators. With half of industry growth coming from Asia, including China, India, and Southeast Asia, decarbonization can work only if airlines from those nations are on board.

Despite the convenience of flying, consumers have said they are increasingly worried about the impact

it has on climate change. Public movements, such as #flygskam ("flight shaming") and Fridays for Future, reflect this sentiment, particularly among millennials.

Investors, for their part, are concerned about the effects of climate risk on airline valuations, with climate-related financial disclosures becoming more common. The frequency of climate-related discussions in European earnings calls with investors increased nearly sevenfold since 2017, according to HSBC data. At the same time, corporate customers turn to airlines for ways to reduce scope-3 emissions<sup>2</sup> incurred from their employees' business travel.

Institutions and governments are announcing policies on CO<sub>2</sub> or SAF. Norway has mandated that

<sup>1</sup> The scenarios include assumptions about improvements in energy efficiency (driven by operational improvements and fleet modifications), the share of zero-emission sustainable aviation fuel in the fuel mix, and reduced travel demand and modal shifts. 2016 was the baseline used for all scenarios, and the business-as-usual outlook is based on McKinsey's 2019 Global Energy Perspective.

<sup>2</sup> Scope-3 emissions are all indirect emissions that occur in the value chain of a reporting company. For an airline, they would include the emissions involved in manufacturing the plane and in preparing the food that people eat in flight, for example.

## Ten questions airline executives should be asking

**The coronavirus pandemic** has created uncertainty for every industry. Airline executives should be asking themselves ten questions about what the crisis means for decarbonization and the possible responses and actions they can take:

1. Will the industry and its emissions shrink in the long run because of a fundamental shift in travel behavior?
2. Will customers become even more serious about demanding sustainable travel, with growing awareness of climate change?
3. What will governments ask in return for state support?
4. Could the coronavirus crisis lead to further industry consolidation, resulting in larger average aircraft capacity, improved seat-load factors, and improved fuel efficiency?
5. Could the crisis present an opportunity to accelerate fleet replacement or renewal?
6. How much upside is left in fuel-efficiency programs to reduce both cost and carbon emissions?
7. Could the crisis be an opportunity to harmonize air-traffic control and reduce on-the-ground and in-flight delays?
8. What does the demand shock from the coronavirus pandemic mean for CORSIA and "cap and trade" systems, such as the European Union's Emissions Trading System?
9. What will a lasting low kerosene price mean for the economic viability of SAF?
10. Could the industry accelerate innovation—for example, into production of SAF?

0.5 percent of aviation fuel in the country must be sustainable this year, growing to 30 percent by 2030. It wants all short-haul flights to be 100 percent electric by 2040. And Canada implemented a carbon tax of 30 Canadian dollars (around \$21) per metric ton of CO<sub>2</sub> in most of its regions, based on the amount of loaded fuel for domestic travel.

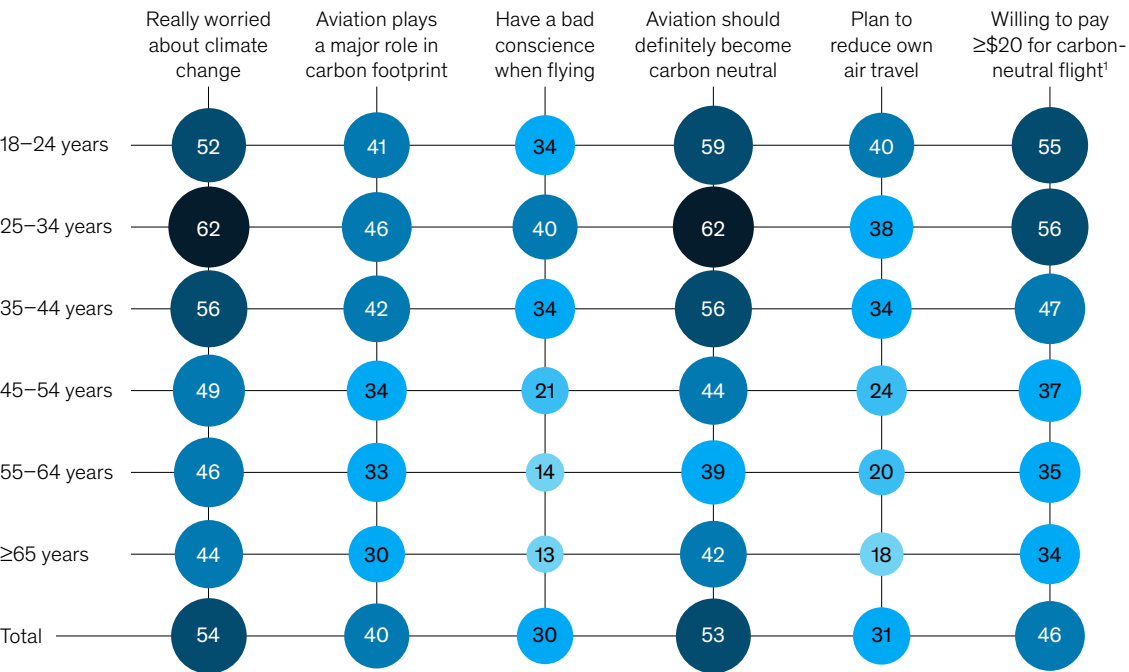
Much of the pressure is rooted in consumer unease. Last summer, McKinsey conducted a survey of roughly 5,300 fliers in 13 aviation markets to get their views on flying and climate change. Although the survey took place well before the coronavirus essentially shut down air travel, more than 50 percent of respondents said they were “really worried” about climate change. Those feelings were higher among

women than men and most pronounced among people aged 34 and younger, suggesting that these perceptions aren’t going away (Exhibit 1).

Roughly a third of respondents said they were planning to reduce their air travel because of climate concerns (Exhibit 2), and most respondents said they were willing to pay somewhat more for carbon-neutral tickets, with fliers aged 18 to 34 willing to pay the most. At the same time, respondents felt that airlines and government subsidies should cover the costs before corporate customers or fliers themselves did. When asked about feasible ways to decarbonize aviation, they ranked carbon offsetting as the least appropriate option.

Exhibit 1  
**Younger airline customers are more concerned about climate change, our survey showed.**

**Attitudes toward carbon-neutral flying, by age group, % of respondents**

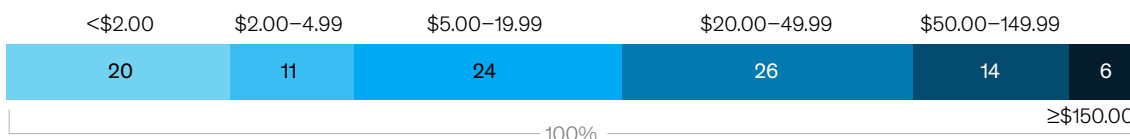


¹For a \$1,000 flight.  
Source: McKinsey CleanSky Survey, July 2019

Exhibit 2

## Many respondents say they are planning to fly less and are willing to pay more for carbon-neutral tickets.

Willingness to pay for carbon-neutral flight, by added cost,<sup>1</sup> % of respondents



**33%**

of respondents believe (other) people should fly less because of climate change

**31%**

of respondents are at least "likely" planning to fly less because of climate change

**8%**

of respondents are "definitely" planning to fly less because of climate change

Note: Figures may not sum to 100%, because of rounding

<sup>1</sup> Based on a \$1,000 flight.

Source: McKinsey CleanSky Survey, July 2019

In the short term, the coronavirus pandemic and the resulting demand shock have reduced carbon emissions. We don't know what the aviation industry will look like after the coronavirus pandemic, but we believe that customer preferences for environmental flying will continue.

### Tech and efficiency gains

Airlines are already working to align emissions cuts with their bottom-line interests. They have encouraged operational efficiency and optimal air-traffic management (ATM) and invested billions of dollars to modernize aircraft with more efficient aerodynamics and engines using lighter-weight materials. However, these actions get the industry only so far, cutting emissions by no more than 20 to 30 percent compared with the do-nothing alternative.

#### Operational efficiency

Fuel typically accounts for 20 to 30 percent of operational costs—one of the largest single cost

items. Every kilogram of kerosene produces 3.15 kilograms of CO<sub>2</sub>.<sup>3</sup> Airlines therefore have an intrinsic motivation for adopting more fuel-efficient flying, taxiing, and airport operations. They are also eking out fuel-efficiency gains by decreasing the extra fuel loaded onto aircraft and introducing lighter materials to reduce aircraft weight.

In a recent survey of airlines, we learned that, despite these efficiency gains, carriers capture only around 50 percent of their full potential. Only a few airlines address their employees' behaviors and mindsets related to fuel. This is a crucial area, since pilots, dispatchers, and other airline employees have considerable discretion in preparing and conducting safe flights, with direct implications for fuel consumption.

To increase fuel efficiency, airlines should identify the areas needing improvement with the help of analytics and systematically drive behavioral change with their frontline employees. For example,

<sup>3</sup>Aviation Carbon Offset Programme: Frequently asked questions," International Air Transport Association, April 30, 2020, iata.org.

in a behavioral-science project, Virgin Atlantic Airways successfully demonstrated how nudging, or using subtle interventions to change behavior, can make pilots use less fuel.

The airline randomly placed all 335 of its pilots into four groups. It informed the members of one group (the control group) that they were part of a fuel-use study, with no further information. It provided the experimental groups with feedback on their fuel use, including monthly assessments on fuel loading, optimized flying, and efficient taxiing. According to the researchers, all three experimental groups saved more fuel than the control group did, and pilots in the “prosocial” group—those told that the company would make a charitable donation if they reached their targets—reported the highest level of job satisfaction.

Airlines also consume additional fuel from zigzagging through nations’ ATM sectors that require predefined handovers. Other inefficiencies include limits on air-traffic-control capacity and a lack of automation in air-navigation services. Eliminating those inefficiencies requires a joint effort from a large group of stakeholders, including governments, regulators, and militaries, which makes the process painfully slow.

#### **New aircraft technology**

Airlines invested almost \$120 billion in new aircraft in 2018 alone, according to Teal data. New models have highly efficient engines, and modern long-haul twin-engine aircraft are replacing four-engine aircraft, which enables up to 20 percent fuel-efficiency improvement per passenger.

Regarding commercial-fleet strategy, executives should consider not just fuel-price predictions but also the future cost of carbon. Applying carbon emissions as a fuel-cost premium could lead to an accelerated fleet rollover and faster adaption of future aircraft technology, including some electrification.

Alternative propulsion (such as via electricity and hydrogen) could one day replace conventional turbine-powered planes, especially smaller aircraft on shorter flights. However, the use of fully electric aircraft carrying more than 100 passengers appears unlikely within the next 30 years or longer. Given the lower energy density of batteries compared to fuels, aircraft would need to carry more than 50 kilograms of battery weight (with today’s technology) to replace one kilogram of kerosene. Because battery weight wouldn’t burn off the way fuel does, carrying that weight for an entire flight would require energy, creating a penalty for longer flights in particular.

Electric propulsion could start with hybrid- or turboelectric flying, enabling further improvements in fuel efficiency as jet engines become smaller and lighter, using less fuel. For example, Ampaire, a Los Angeles–based start-up, is working with Mokulele Airlines, an interisland carrier in Hawaii, on hybrid-electric flights for aircraft with around ten passengers.

Aircraft could also be powered by hydrogen, either from direct combustion (hydrogen turbine) or via a fuel cell. Hydrogen emits no CO<sub>2</sub> during the combustion process and allows for significant reduction of other elements that drive global warming, such as soot, nitrogen oxides, and high-altitude water vapor. (Hydrogen can also be a feedstock for SAF; more on that in a later section.)

However, liquified hydrogen would require four times the volume of kerosene, so its use would reduce space for customers or cargo. Also, airports would need new parallel refueling infrastructures, including fuel trucks able to store liquified hydrogen. Refueling time would grow for longer-range aircraft, affecting gate and aircraft utilization. Smaller aircraft powered with hydrogen could become feasible in the next decade. For aircraft with more than approximately 100 passengers, significant aircraft-technology development would be required,

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<sup>4</sup>McKinsey analysis shows that only 4 percent of worldwide emissions result from flights of fewer than 500 kilometers; 13 percent are from flights of fewer than 1,000 kilometers.

and infrastructure constraints would need to be overcome.

### **Intermodal shift**

Trains and buses generate less CO<sub>2</sub> on a per-passenger basis than planes do (and rail freight can be a lower-emission alternative for air cargo). Airlines can work with rail and bus companies to offer a more integrated service for short connections and when alternative means of transport are available. Examples abound, often in Europe, such as the rail link between the United Kingdom and Europe that cut back the need for flying. But carbon savings here don't make a large dent in overall airline emissions,<sup>4</sup> nor are they a great option for airlines' bottom lines.

### **Carbon offsetting**

Carbon offsetting, or CO<sub>2</sub> compensation, provides a large-scale and industry-agnostic means of compensating for CO<sub>2</sub> emissions by reducing emissions elsewhere. Airlines are on board with offsetting; indeed, the industry is expected to be a key sponsor for global reforestation. Offsetting is also the basis for such market-based measures as Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), the International Civil Aviation Organization's carbon-reduction initiative.

Offsetting allows worldwide investment in projects to compensate for emissions, independent of buyers' own efforts to reduce their footprints. Planting trees and letting them grow to capture CO<sub>2</sub> can cost as low as \$5 to \$10 per metric ton of CO<sub>2</sub> captured. That translates into a ticket-price increase of less than \$1 per passenger on a short-haul flight. Besides nature-based solutions such as planting trees, offsetting projects can be related to resource recovery (such as methane capture from landfills), renewable energy, energy efficiency, and fuel switching, among other areas.

Yet offsetting as a longer-term solution is controversial. Some critics view it as an attempt at greenwashing. Many also worry that offsetting might relieve the pressure on buyers to reduce

their emissions in other ways: they might feel better by offsetting and not consider enacting other emission-cutting measures. A credible environmental-footprint strategy includes reducing emissions through renewable fleets, fuel efficiency, and other measures as the role of SAF grows over time, in addition to offsetting emissions that remain.

Many airlines have made large offset commitments that go beyond CORSIA and offer their customers the option to pay offsetting costs themselves. Overall, however, only about 50 percent of airlines offer customers an opportunity to offset flight emissions, and the process to do so can be cumbersome, with customers redirected to a separate website to opt-in. As our survey showed, very few fliers—less than one percent—make use of voluntary carbon offsetting.

### **Sustainable aviation fuel**

SAF is a solution that can achieve full decarbonization, but it comes with challenges on both the supply and demand fronts. When burned, SAF creates the same amount of CO<sub>2</sub> emissions as conventional jet fuel. The improvement results from the fact that its production process absorbs CO<sub>2</sub>, leading to a reduction in CO<sub>2</sub> emissions of 70 to 100 percent on a life-cycle basis.

In a 1.5°C pathway, our analysis found that SAF would have to account for 20 percent of jet fuel by 2030, or, at a minimum, 10 percent in a scenario in which transportation lags in decarbonization compared with other sectors.

Use of advanced biofuels is a likely near-term solution. The technical feasibility of fuel made from vegetable or waste oils is proven, the product is certified, and some airlines use the fuel in daily operations. But getting the appropriate feedstock and supply chain in place is difficult; building production facilities and refineries is costly. Used cooking oil, a popular ingredient for biofuel, has fragmented availability and is expensive to collect. Other vegetable oils have high costs of production, collection, transportation, and conversion to fuel.

Feedstock resources also involve other environmental risks, such as deforestation and the creation of monocultures. Feedstock sources for biofuels must be selected thoughtfully to limit “food versus fuel” challenges.

Some airlines, including Cathay Pacific Airways and United Airlines, have invested in facilities to demonstrate how municipal household waste could be gasified and subsequently turned into jet fuel. In some regions, the fermentation of wood residues into sustainable kerosene has shown potential as a viable path.

Alternatively, the use of synfuels derived from hydrogen and captured carbon emissions could become a scalable option. Such synfuels require water, renewable electricity to produce hydrogen, and CO<sub>2</sub>. Today, these power-to-liquid fuels are several times the cost of conventional kerosene, though we expect a significant cost reduction for

green hydrogen (via reduced costs of renewable electricity and “electrolyzers”) in the coming years. In a first step, CO<sub>2</sub> could be captured as waste gas from carbon-intensive industries, such as steel, chemicals, and cement.

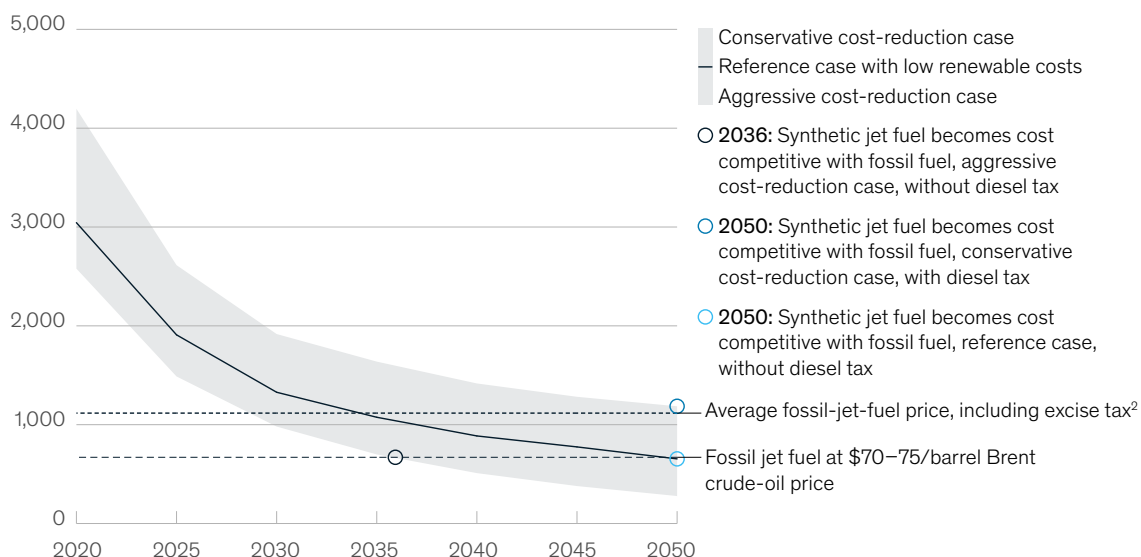
Long term—and to become net-zero CO<sub>2</sub>—the required CO<sub>2</sub> needs to be extracted from the carbon cycle (taken from the air with direct air capture). While this is costly today, the process benefits from cheaper renewable-electricity generation in the future.

While synfuels could become an answer to cutting emissions over the long run, it is unclear, at this point, which SAF sources will emerge as winners. A McKinsey analysis suggests that while current SAF costs are high in relation to kerosene cost, they will come down over time and could reach breakeven between 2030 and 2035, in an optimistic scenario (Exhibit 3).

Exhibit 3

## With low renewable costs or regulation, synthetic jet fuel could become cost competitive with fossil jet fuel.

Cost of synthetic-jet-fuel production, \$/metric ton, 2019<sup>1</sup>



<sup>1</sup> Costs of synthetic fuel produced in a facility built in the corresponding year. 1 metric ton = 2,205 pounds.

<sup>2</sup> Assumed similar to EU diesel tax for road use (\$0.50/liter).

Source: Energy Insights by McKinsey



In effect, SAF presents a classic chicken-and-egg problem. Airlines don't yet have a viable business case for buying SAF; therefore, its production volume is small, with little economies of scale and insufficient funding (Exhibit 4).

### Wanted: More stakeholders for sustainable aviation fuel

Breaking through the which-comes-first problem with SAF would involve a number of groups, each doing its part to put the puzzle together. First, airlines could build and orchestrate a consortium of stakeholders that includes technology providers and oil companies to drive demand and help bridge the cost gap. For example, airlines could commit to buying SAF at a predefined price, or at a price differential to traditional jet fuel, which would eliminate market risks for fuel suppliers.

Second, financial institutions could provide venture capital for building SAF-production facilities and new infrastructure that allows for the anticipated cost

savings. Building a coalition of airlines could increase the required volume, resulting in scale effects.


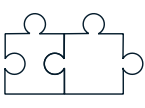
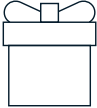




Third, airlines could work with B2B customers willing to pay a premium for the opportunity to decarbonize their employees' footprints. Microsoft committed to reducing its environmental footprint by promoting SAF and paying for the cost premium. For individual customers, airlines could use loyalty-program rewards as incentives to offset CO<sub>2</sub> through SAF use.

Fourth, policy makers at domestic and regional levels could play a critical role by creating incentives for SAF production and setting appropriate targets. Countries such as Canada and Norway that are willing to apply blending mandates are moving forward on this front. Policy makers could also reallocate aviation taxes back to the industry to fund decarbonization, closing the remaining cost gap between conventional kerosene and SAF.

Exhibit 4

## How to overcome sustainable aviation fuel's chicken-and-egg problem.

### Potential measures for spurring sustainable-aviation-fuel (SAF) production and growth

						
<b>Policy and regulation</b> Apply effective policy measures, such as blending mandates (eg, policy in Norway)	<b>B2B contracts</b> Negotiate corporate-customer deals that involve SAF financing	<b>B2C incentives</b> Use airline-loyalty programs to incentivize customers to compensate for CO <sub>2</sub> through SAF	<b>Demand and scale</b> Build clusters of like-minded peers and create large-scale off-take agreements	<b>Airports and fee structures</b> Involve airports with suitable infrastructure and use fee structures to increase SAF uptake	<b>Prioritized aviation</b> Accelerate transition to alternative energy sources for road transport to make biofuels available for aviation	<b>Accelerated R&amp;D</b> Motivate companies, particularly in oil and gas, to increase R&D

The coronavirus pandemic has hit aviation hard. Yet as the industry emerges from this painful period, there is an opportunity to move closer to low-carbon goals.

The aviation industry has made great strides in fuel efficiency and operational advancements. But to reach global emission-reduction targets, it will need to move to the next level of decarbonization, and SAF is an option that could get it there. Bolder

moves and much deeper collaboration among stakeholders are necessary to build financial structures and programs that can help funnel capital into SAF production.

Because the aviation industry has such long-lived assets, making decisions now is crucial. Finding solutions that bring the industry in line with global emission goals will help ensure that future generations won't feel the flight shaming of today.

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# Climate risk and decarbonization: What every mining CEO needs to know

Building a climate strategy won't be quick or easy—but waiting is not an option.

*by Lindsay Delevingne, Will Glazener, Liesbet Grégoir, and Kimberly Henderson*

**In the mining industry**, the impact of climate change and how the industry can respond to it has increasingly been a topic of discussion over the past decade.

Mining is no stranger to harsh climates; much of the industry already operates in inhospitable conditions. But forecasts of hazards such as heavy precipitation, drought, and heat indicate these effects will get more frequent and intense, increasing the physical challenges to mining operations.

Under the 2015 Paris Agreement, 195 countries pledged to limit global warming to well below 2.0°C, and ideally not more than 1.5°C above preindustrial levels. That target, if pursued, would manifest in decarbonization across industries, creating major shifts in commodity demand for the mining industry and likely resulting in declining global mining revenue pools. Mining-portfolio evaluation must now account for potential decarbonization of other sectors.

The mining sector itself will also face pressure from governments, investors, and society to reduce emissions. Mining is currently responsible for 4 to 7 percent of greenhouse-gas (GHG) emissions globally. Scope 1 and Scope 2 CO<sub>2</sub> emissions from the sector (those incurred through mining operations and power consumption, respectively) amount to 1 percent, and fugitive-methane emissions from coal mining are estimated at 3 to 6 percent.<sup>1</sup> A significant share of global emissions—28 percent—would be considered Scope 3 (indirect) emissions, including the combustion of coal.

The mining industry has only just begun to set emission-reduction goals. Current targets published by mining companies range from 0 to 30 percent by 2030, far below the Paris Agreement goals.<sup>2</sup> Mines theoretically can fully decarbonize (excluding

fugitive methane) through operational efficiency, electrification, and renewable-energy use. Capital investments are required to achieve most of the decarbonization potential, but certain measures, such as the adoption of renewables, electrification, and operational efficiency, are economical today for many mines.

To address climate risk for miners, we examine three questions in this article: Which mining assets are most at risk from physical climate change? How could decarbonization shift demand for key minerals? And how can mining companies decarbonize their own operations? We then lay out the operational, investment, and portfolio options that mining executives can use to create an actionable climate strategy and set ambitious targets.

## Vulnerable mining assets

Despite changing climate conditions, options exist to improve the resiliency of mining assets to certain physical effects. We evaluated the impact of water stress and flooding in detail and suggest how operators might mitigate these risks.

### Water stress

Climate change is expected to cause more frequent droughts and floods, altering the supply of water to mining sites and disrupting operations. We recently ran and analyzed a water-stress and flooding scenario using McKinsey's MineSpans database on copper, gold, iron ore, and zinc.<sup>3</sup>

We found that today, 30 to 50 percent of production of these four commodities is concentrated in areas where water stress is already high.<sup>4</sup> In 2017, these sites accounted for roughly \$150 billion in total annual revenues and were clustered into seven water-stress hot spots for mining: Central Asia, the

<sup>1</sup> Emission estimates are based on research by McKinsey's Basic Materials Institute. The range of fugitive-methane emissions is a function of the time horizon at which the warming impact of methane is calculated. The lower number refers to global-warming potential on a 100-year time frame (GWP100), and the higher number refers to global-warming potential on a 20-year time frame (GWP20).

<sup>2</sup> Limiting climate change will require a significant reduction in greenhouse-gas emissions between 2010 and 2050: a 41 to 72 percent decrease for a 2.0°C scenario and a 78 to 89 percent decrease for a 1.5°C scenario, according to data from the Intergovernmental Panel on Climate Change (IPCC). This industry target range does not include Scope 3 emissions.

<sup>3</sup> We looked at current and projected water stress, defined as the ratio of the amount of water used over the total quantity of water available locally, from the World Resources Institute's Aqueduct Water Risk Atlas. We then overlaid data from McKinsey's MineSpans database on the location, production, and type of more than 3,000 mines worldwide for four major extracted commodities: copper, gold, iron ore, and zinc.

<sup>4</sup> "High" water stress denotes a ratio of water demand to water supply of 40 percent or greater.



Chilean coast, eastern Australia, the Middle East, southern Africa, western Australia, and a large zone in western North America.

Climate science indicates that these hot spots will worsen in the coming decades.<sup>5</sup> In Chile, 80 percent of copper production is already located in extremely high water-stressed and arid areas; by 2040, it will be 100 percent. In Russia, 40 percent of the nation's iron ore production, currently located in high water-stressed areas, is likely to move to extreme water stress by 2040.

Mining regions not accustomed to water stress are projected to become increasingly vulnerable. By 2040, 5 percent of current gold production will likely shift from low–medium water stress to medium–high, 7 percent of zinc production could move from medium–high to high water stress, and 6 percent of copper production could shift from high to extremely high water stress (Exhibit 1). Depending on the water intensiveness of the processing approach, such changes, while seemingly minor in percentage terms, could be critical to a mine's operations or license to operate.

Mining executives in these regions are acutely aware of the water issue. For instance, Leagold Mining recently shut down its RDM gold mine in Brazil for two months because of drought conditions, even though it had built a dam and a water pipeline. Even in areas with low water stress, certain water-intensive mining processes are jeopardized. In Germany—not a country known for being vulnerable to drought—a potash miner was forced to close two locations because of severe water shortages in the summer of 2018, losing nearly \$2 million a day per site. The frequency and severity of these conditions are expected to increase along with the current climate trajectory.

Since water stress is likely to increase at different rates from place to place, mining executives will need to look at local water-stress projections for

their individual sites and determine where the worst effects are likely to occur.

To improve resiliency, companies can reduce the water intensity of their mining processes. They can also recycle used water and reduce water loss from evaporation, leaks, and waste. Anglo American improved evaporation monitoring at its Drayton mine dam in Australia, for example. Mining companies can prevent evaporation by putting covers on small and medium dams.

In the long term, more capital-intensive approaches are also possible. New water infrastructure, such as dams and desalination plants, is expensive but sometimes necessary. Companies can also rely on so-called natural capital, like wetland areas, to improve groundwater drainage.

The option of securing water rights is becoming harder and can take years of engagement because of increased competition for natural resources and tensions between operators and local communities. Basin and regional planning with regulatory and civic groups is an important strategy but cannot alone solve the underlying problem of water stress.

### Flooding

Flooding from extreme rains can also cause operational disruptions, including mine closure, washed-out roads, and unsafe water levels in tailing dams. At one open-pit coal mine, we observed 10 percent annual production losses from wet weather. Flooding affects some commodities more than others, based on their location; in our analysis, iron ore and zinc are the most exposed to extremely high flood occurrence, at 50 percent and 40 percent of global volume, respectively.<sup>6</sup>

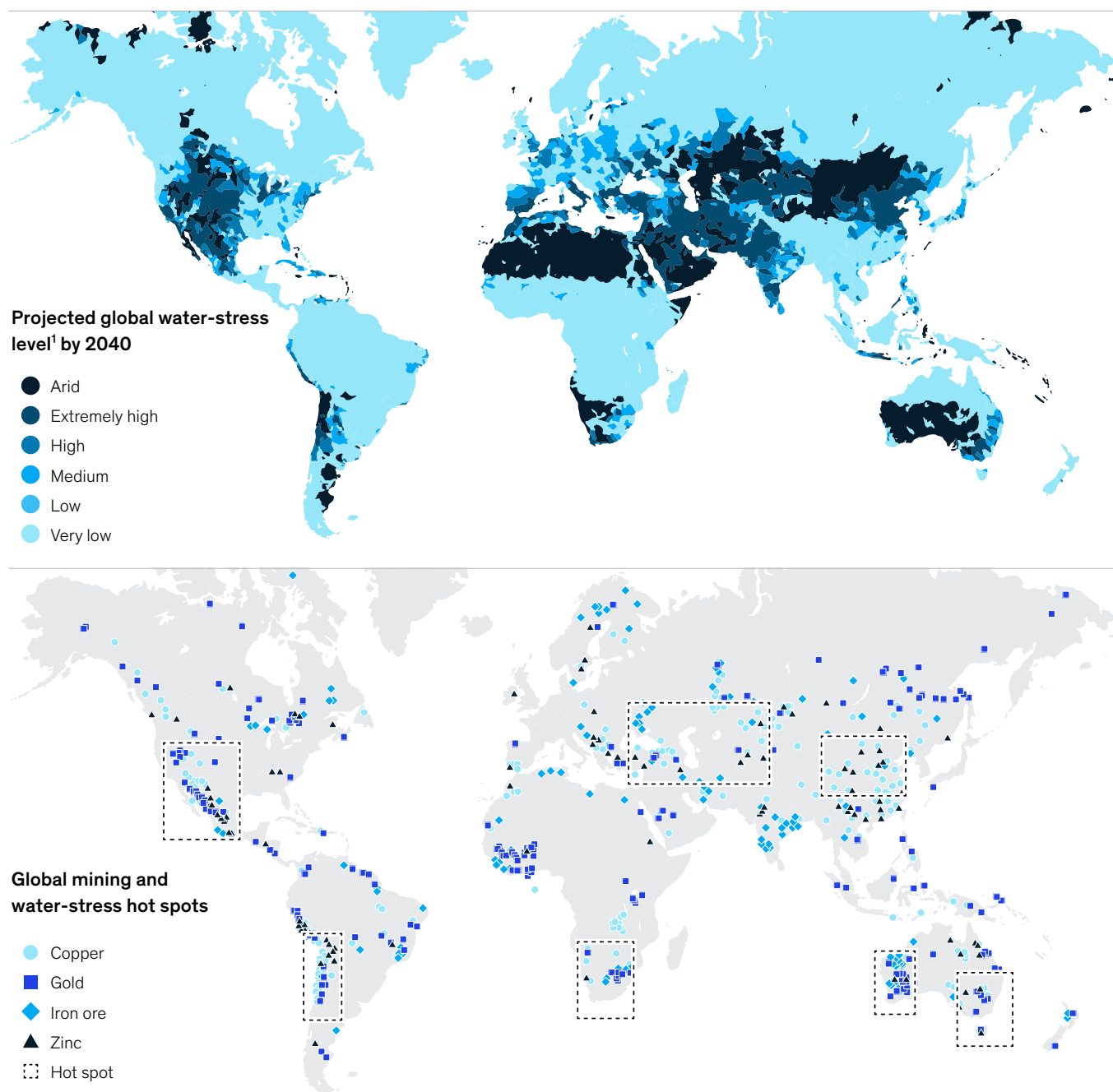
The problem is expected to get worse, particularly in six “wet spots” likely to experience a 50 to 60 percent increase in extreme precipitation this century: northern Australia, South America, and southern Africa during Southern Hemisphere

<sup>5</sup>According to recent reports from the Intergovernmental Panel on Climate Change, including *Global warming of 1.5°C*, October 2018, and *Fifth assessment report*, 2014, both on [ipcc.ch](http://ipcc.ch).

<sup>6</sup>We looked at current mine production from our MineSpans database and overlaid it on flooding estimates from the Aqueduct Water Risk Atlas's business-as-usual scenario, representing a global mean temperature increase of 2.6°C to 4.8°C.

Exhibit 1

By 2040, key mining regions could be increasingly vulnerable to water stress.



<sup>1</sup>Water stress defined as ratio of water demand to supply.

Source: Aqueduct Water Risk Atlas, World Resources Institute, 2015, wri.org; MineSpans by McKinsey



summer, and central and western Africa, India and Southeast Asia, and Indonesia during Southern Hemisphere winter.

To address high-water concerns, companies can adopt flood-proof mine designs that improve drainage and pumping techniques. They can adapt roads (such as by using hard metal or crusted rock for speed drying) or build sheeted haul roads, as First Quantum Minerals did at its Sentinel copper mine in Zambia. They can also use conveying methods that don't rely on trucking (such as by creating a full in-pit crushing and conveying system).

### **Other climate factors**

Extreme weather combined with sea-level rise can damage processing or transportation infrastructure located near coastlines.

Extreme heat in already hot places—particularly Australia, China, and parts of North and West Africa—can decrease worker productivity and raise cooling costs. It can also put workers' health (and sometimes their lives) at risk. Indirect socioeconomic consequences from climate change can also affect the political environment surrounding a mine.

## **Shifting demand for minerals**

Significant growth of low-carbon technologies will occur if industries commit to cutting emissions in line with Paris Agreement targets. Technologies that support decarbonization include wind turbines, solar photovoltaics, electric vehicles, energy storage, metal recycling, hydrogen fuel cells, and carbon capture and storage.

The mining industry will be part of the decarbonization solution by providing the raw materials needed for these technologies. Simultaneously, their growth will alter demand patterns for upstream mining commodities.

We developed a theoretical commodity-demand-shift scenario, quantifying the impact on commodity

demand by 2030, assuming global warming is limited to 2°C (Exhibit 2). Because the exact scale and mix of decarbonization technologies in a 2°C scenario is far from certain, the demand shifts are displayed as directional movements when compared with business-as-usual forecasts.

Coal, currently about 50 percent of the global mining market, would be the most obvious victim of such shifts. Decarbonization of the power sector would mean taking net GHG emissions to zero, implying an almost complete reduction in the combustion of coal. And if metal companies switch to hydrogen and biofuels as energy sources, demand for metallurgical coal will weaken. While coal demand is still rising, capital investments in coal mines have become more difficult, with public opinion hardening and some banks pulling away from the industry in certain regions.

More energy-efficient processing and widespread recycling would put pressure on virgin-ore markets. In a 2°C scenario, bauxite, copper, and iron ore will see growth from new decarbonization technologies offset by increased recycling rates, as a result of the growing circular economy and focus on metal production from recycling versus virgin ore.

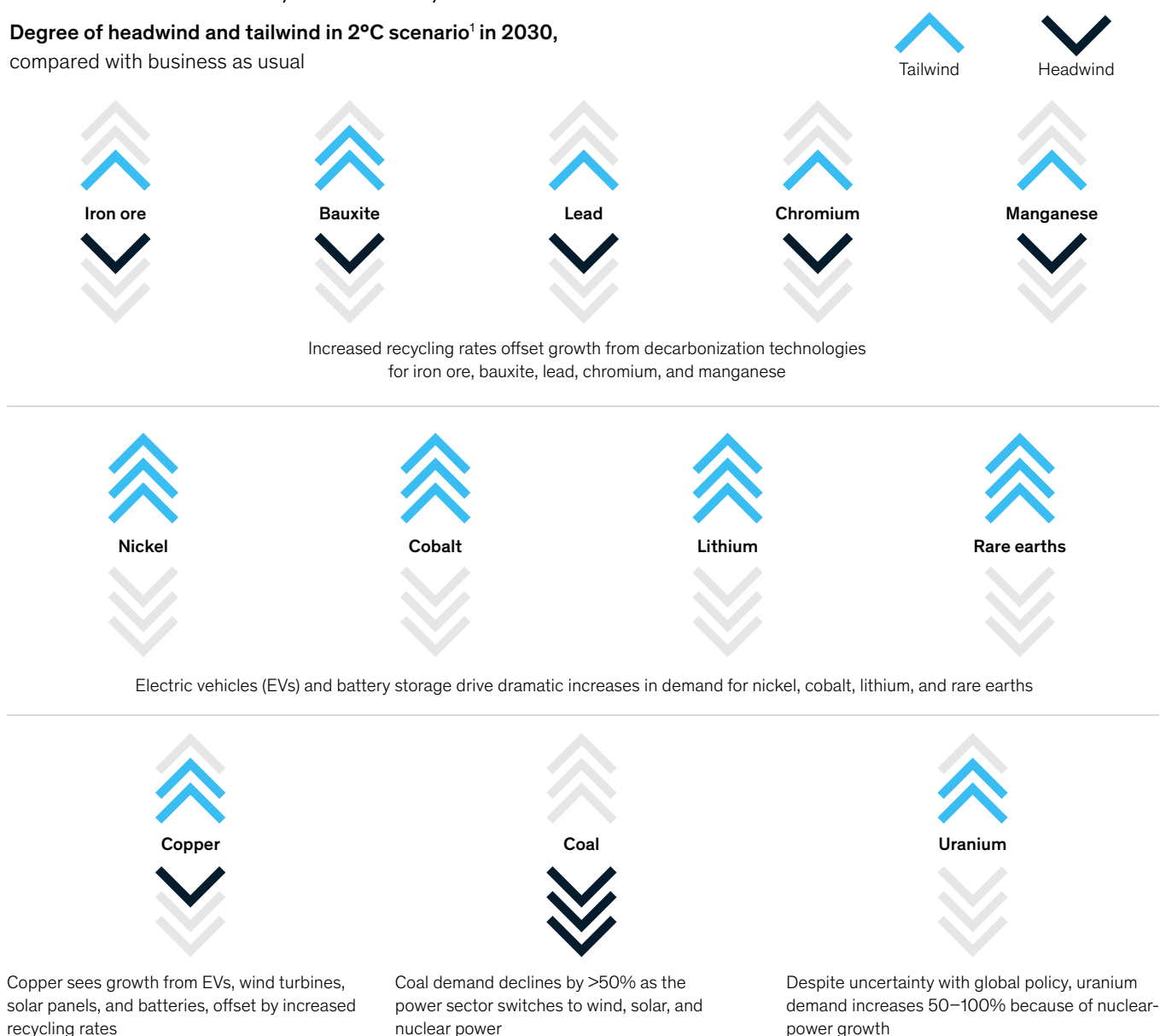
At the other end of the spectrum, niche minerals could experience dramatic growth. As the global electrification of industries continues, electric vehicles and batteries will create growth markets for cobalt, lithium, and nickel. Emerging technologies such as hydrogen fuel cells and carbon capture would boost demand for platinum, palladium, and other catalyst materials, while rare earths would be needed for wind-turbine magnets.

Fully replacing revenues from coal will be difficult. Yet many of the world's biggest mining companies will need to rebalance nondiverse mineral portfolios. Many of the largest mining companies derive the bulk of their earnings from one or two commodities. Copper-heavy portfolios may benefit from demand growth related to widespread electrification, for example. And iron ore— and aluminum-heavy

Exhibit 2

**A 2°C scenario would be a significant deviation from business as usual, leading to a range of demand shifts for many minerals by 2030.**

**Degree of headwind and tailwind in 2°C scenario<sup>1</sup> in 2030,**  
compared with business as usual



<sup>1</sup>Based on IEA 2°C scenario.

Source: *Energy Technology Perspectives 2017*, IEA, June 2017, [iea.org](http://iea.org); *The growing role of minerals and metals for a low carbon future*, World Bank, June 2017, [documents.worldbank.org](https://documents.worldbank.org); World Bank; Energy Insights by McKinsey; McKinsey analysis; McKinsey Basic Materials Institute

portfolios may see an upside from decarbonization technologies, but they are also more likely to be hit by rising recycling rates.

Niche commodities probably will not be able to replace the magnitude of earnings from coal, but they could help manage losses (Exhibit 3). For miners, a rebalanced portfolio would require agility—sophisticated market intelligence and flexible assets—which could become a competitive advantage in enabling responses to mineral-demand shifts.

There is a growing interest in low-carbon metals from downstream-production processes. For example, some automotive companies that manufacture products using a carbon-neutral process are asking suppliers to deliver carbon-

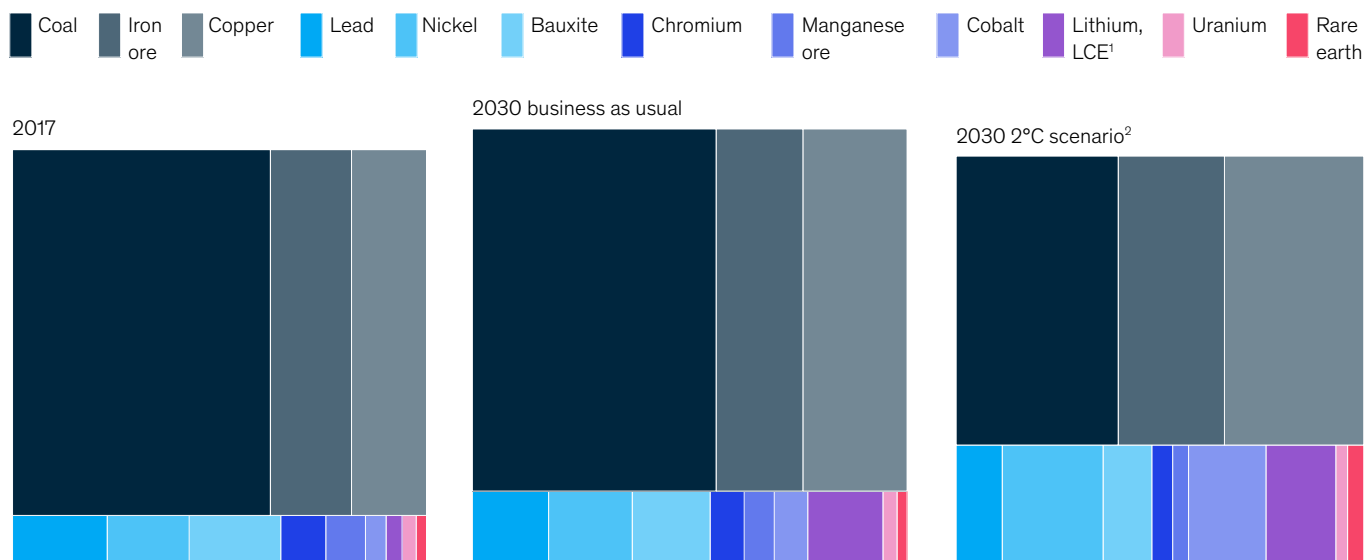
neutral parts, often made with niche metals. Technology giant Apple has announced the purchase of carbon-free aluminum for its products. Although metals are not yet priced on their CO<sub>2</sub> footprint, that day could come.

A legislated carbon price could also shift the competitive dynamics. A local price on carbon—in any form—affects advantages in different mining regions, commodities, processing routes, and companies. In Europe, for example, the Emission Trading System (ETS) is entering a new phase of emission-reduction targets. The so-called Green Deal on emission regulations, while in its early stages, could lead to a higher carbon price for European primary industries, resulting in possible competitive disadvantages for some companies in global markets.

Exhibit 3

## In a 2°C scenario, niche commodities probably won't replace earnings from coal and iron ore but could help ease losses.

Market size for minerals by scenario driven by demand shifts, excluding price effects, %



¹Lithium-carbonate equivalent.

²Based on IEA 2°C scenario.

Source: *Energy Technology Perspectives 2017*, IEA, June 2017, [iea.org](http://iea.org); *The growing role of minerals and metals for a low carbon future*, World Bank, June 2017, [documents.worldbank.org](http://documents.worldbank.org); World Bank; Energy Insights by McKinsey; McKinsey analysis; McKinsey Basic Materials Institute

Besides shifting commodity demand, major reductions in carbon emissions would also affect commodity prices. A global carbon price, investments to decarbonize operations, and strong growth in commodities requiring the opening of new mines would increase mining costs, leading to higher commodity prices. The commodities at stake and the potential price growth are functions of how and at what pace decarbonization occurs.

## How mining can decarbonize

The mining industry generates between 1.9 and 5.1 gigatons of CO<sub>2</sub> equivalent (CO<sub>2</sub>e) of GHG emissions annually. The majority of emissions in this sector originate from fugitive coal-bed methane that is released during coal mining (1.5 to 4.6 gigatons), mainly at underground operations.<sup>7</sup> Power consumption in the mining industry contributes 0.4 gigaton of CO<sub>2</sub>e.

Further down the value chain—what could be considered Scope 3 emissions<sup>8</sup>—the metal industry contributes roughly 4.2 gigatons, mainly through steel and aluminum production. Coal combustion for the power sector contributes up to roughly ten gigatons of CO<sub>2</sub>.

Any serious effort to implement Paris Agreement goals would require a major contribution from the entire value chain. To stay on track for a global 2°C scenario, all sectors would need to reduce CO<sub>2</sub> emissions from 2010 levels by at least 50 percent by 2050.<sup>9</sup> To limit warming to 1.5°C, a reduction of at least 85 percent would likely be needed.<sup>10</sup> Mining

companies' published emission targets tend to be more modest than that, setting low targets, not setting targets beyond the early 2020s, or focusing on emission intensity rather than absolute numbers.

External pressure to decarbonize depends on a mix of factors, including involvement by investors, regulators, and customers. Decarbonization will also vary by geography, segment, and executives' own priorities. The Task Force on Climate-related Financial Disclosures (TCFD), a coalition with support from more than 300 investors with nearly \$34 trillion in assets under management, recommends that companies report their "transition risks" under a 2°C decarbonization scenario.

Decarbonizing the mining industry would require a serious effort by the coal industry, particularly in tackling fugitive methane. Solutions for capturing methane (and using it to generate power) exist, but they are not commonly implemented. In the United States, for instance, the Coalbed Methane Outreach Program—part of the Environmental Protection Agency—works with the coal-mining industry to support project development and to overcome technical and other barriers to implementation. But there are no ready solutions for all types of mines, and the investment is not economical in many cases.

To create a baseline of current mining emissions, we overlaid our MineSpans database of mines' operational characteristics with emission factors by fuel source (Exhibit 4). Across commodities, electricity usage amounts to 0.3 gigaton and diesel to roughly 0.1 gigaton.

<sup>7</sup> Greenhouse-gas emissions from fugitive methane are estimated based on average methane-emission factors, as published by the Intergovernmental Panel on Climate Change (IPCC). The range is because of time-frame considerations when converting methane to CO<sub>2</sub> equivalent. The lower number refers to global-warming potential on a 100-year time frame (GWP100), and the higher number refers to global-warming potential on a 20-year time frame (GWP20). In the GWP20 calculation, the contribution of fugitive methane is three times stronger.

<sup>8</sup> A significant share of global emissions would be considered Scope 3 emissions for miners. Coal-based power accounts for roughly 20 percent of global emissions (excluding power for mining and metals); coal use in industry accounts for a further 8 percent. Additional Scope 3 emissions include gas combustion to process metals and emissions generated upstream for the production of mining equipment.

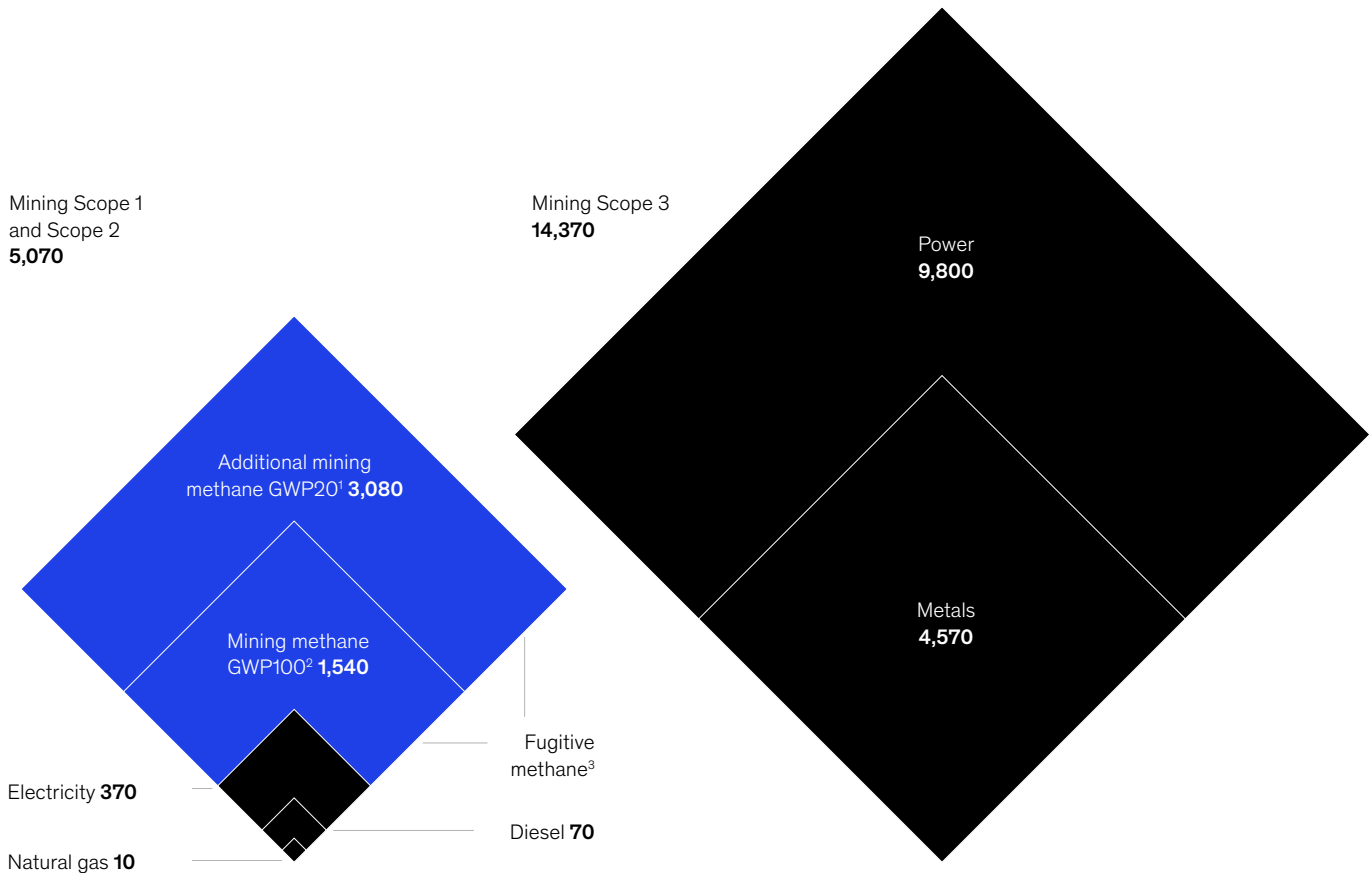
<sup>9</sup> Intergovernmental Panel on Climate Change (IPCC) data.

<sup>10</sup> Based on McKinsey's 1.5°C-scenario analysis, achieving net-zero global CO<sub>2</sub> emissions by 2050 would require an 85 percent reduction of gross emissions, with the remaining 15 percent offset by CO<sub>2</sub>-removal solutions, such as reforestation and bioenergy with carbon capture and storage.

Exhibit 4

**The majority of greenhouse-gas emissions in mining are generated in downstream industries (Scope 3) and during coal mining (fugitive methane).**

**Greenhouse-gas emissions, by industry, by type, megatons per year of CO<sub>2</sub> equivalent**



<sup>1</sup>GWP20 = global-warming potential on a 20-year time frame.

<sup>2</sup>GWP100 = global-warming potential on a 100-year time frame.

<sup>3</sup>Fugitive methane is converted to CO<sub>2</sub> on both GWP100 (conversion factor 28) and GWP20 (conversion factor 84).

Source: US Federal Highway Administration; McKinsey analysis

We then estimated the possible impact of, and constraints on, several mining-decarbonization levers (Exhibit 5).

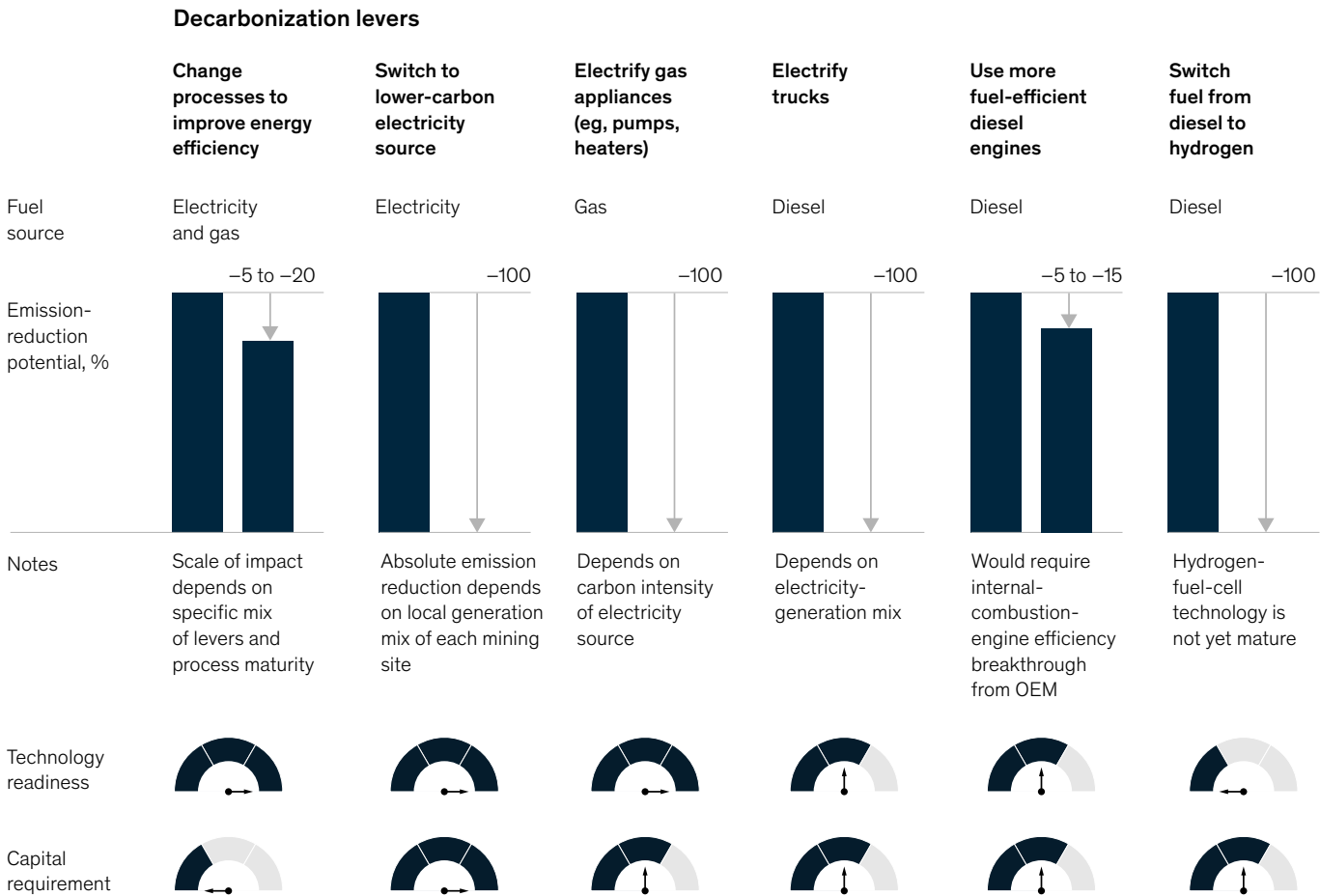
The decarbonization potential for mines varies by commodity, mine type, power source, and grid emissions, among other factors. Across the industry, noncoal mines could fully decarbonize by using multiple levers. Some are more economical than others—operational efficiency, for example, can

make incremental improvements to the energy intensity of mining production while requiring little capital expenditure.

Moving to renewable sources of electricity is becoming increasingly feasible, even in off-grid environments, as the cost of battery packs is projected to decline 50 percent from 2017 to 2030. Codelco, for instance, uses solar power for one of its copper mines in Chile, and Fortescue Metals is

Exhibit 5

There are several options to reduce on-site emissions from mines.



Source: International Council on Clean Transportation; McKinsey analysis

investing in renewable energy at its iron ore mines in the Pilbara region in Australia. BHP recently signed contracts for renewable energy at its Escondida and Spence copper mines.

Electrification of mining equipment, such as diesel trucks and gas-consuming appliances, is only starting to become economical. Right now, only 0.5 percent of mining equipment is fully electric. However, in some cases, battery electric vehicles

have a 20 percent lower total cost of ownership versus traditional internal-combustion-engine vehicles. Newmont, for example, recently started production at its all-electric Borden mine in Ontario, Canada.

Some decarbonization actions will benefit the bottom line, while others will prioritize social responsibility. Future regulatory and technological developments may change the viability of certain



actions, but one thing is certain: the business case will vary for each mine—and each company.

To date, mining companies have viewed sustainability mostly through a local lens, but achieving a 1.5°C to 2.0°C pathway will require significant global action. Several big mining companies have installed their own sustainability committees, signaling that mining is joining the wave of corporate sustainability reporting and activity. Reporting emissions and understanding decarbonization pathways are the first steps toward setting targets and taking action.

### **A checklist for top executives**

To respond to the impact of climate change, mining executives should take five main actions.

First, perform an end-to-end diagnostic of climate change's effects on the business so that you know which assets to protect from physical climate change and which stand to gain or lose from decarbonization. The physical risks of climate change, such as water stress, precipitation, and heat, must be evaluated at a localized, asset-specific level. Such analyses may require technical expertise from outside the organization, tailored to the company's specific footprint and operations.

Decarbonization scenarios should be built into demand forecasts for a company's commodities, including accounting for at-scale renewables, metal recycling, and even metal-process-route shifts. Site-specific baseline emissions should be understood, and potential abatement levers evaluated.

Second, mobilize the C-suite and the board. Climate change—the risks and the opportunities—should be considered a board-level topic, given its systemic, long-term, and potentially dramatic impact.

Ambitious climate targets that come from the top—an approach the mining sector is only beginning to embrace—can create value and spur employee and stakeholder engagement.

Third, focus on operational transformation, investments, and innovation. Several percentage points of no-regrets energy-efficiency moves can often be found at mines, and climate targets can focus efforts to unearth them. Shifting to renewables can offer benefits, such as lower electricity costs and reduced volatility. Bolder investments—such as reimagining processes to account for shifting water demand and embarking on a decarbonization plan using both existing technologies and promising new alternatives—may also be made.

Fourth, evaluate and potentially reshape your portfolio. Climate change introduces unpredictability, requiring “climate intelligence” to be embedded in decision-making processes, such as capital allocation. The ability to move relatively quickly in or out of niche materials will become valuable.

Fifth, continue to engage through reporting, partnerships, and other proactive measures. Some investors, such as those signed with the TCFD, now require climate-risk disclosures; this will become more important as climate expectations mature. Such reporting can serve as a forcing device for internal change. Industry coalitions—including peers, customers, suppliers, and society at large—

can aid engagement. Additionally, an ambitious agenda on one of society's most difficult goals can be motivational for employees and external stakeholders alike.

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Action on climate change is growing in the mining industry, as companies review commodity portfolios, set targets, and engage with stakeholders.

Yet these actions are too modest to reach the 1.5°C to 2.0°C scenario and may not be keeping up with society's expectations—as increasingly voiced by investors seeking disclosures, companies asking their suppliers to decarbonize, and communities advocating for action on environmental issues. Mining companies concerned about their long-term reputation, “license to operate,” or contribution to decarbonization efforts may start to consider more aggressive decarbonization and resilience plans.

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# Charging electric-vehicle fleets: How to seize the emerging opportunity

By 2030, the US market for energy-optimization services to support the charging of electric-vehicle fleets could be worth \$15 billion per year. Here is how companies can capture the opportunity.

*by Rob Bland, Wenting Gao, Jesse Noffsinger, and Giulia Siccardi*



**As more people** and organizations acquire electric vehicles (EVs), companies will have chances to lift their revenues not only by selling more electric power and charging infrastructure but also by providing services that support the charging of EVs. EV fleets represent a particularly promising segment of the potential market for charging services, which can help fleet operators reduce their costs by procuring and managing energy in efficient ways. In the United States, the market for fleet-charging services could amount to \$15 billion per year by 2030. Although this market is fragmented and undeveloped, it is not too early for companies to position themselves to compete in it. Companies should recognize that delivering these services will likely require new business models—and prepare accordingly.

### Finding the profit in EV fleet charging

Thanks to such factors as falling costs, widening availability, and support from policy makers, US sales of commercial EVs have continued to grow. Looking ahead, the operators of vehicle fleets may be especially enthusiastic buyers of EVs. EVs do cost more than comparable vehicles with internal combustion engines (ICEs). However, their superior efficiency, the moderate price of electricity, and the high utilization of fleet vehicles allow fleet operators to quickly recoup the extra up-front cost of an EV and achieve a lower total cost of ownership. Our estimate suggests that fleet EVs can have a total cost of ownership that is 15 to 25 percent less than that of equivalent ICE vehicles by 2030.<sup>1</sup>

Assuming widespread EV adoption, McKinsey projects that commercial and passenger fleets in the United States could include as many as eight million EVs by 2030 (compared with fewer than

5,000 in 2018), which would amount to between 10 and 15 percent of all fleet vehicles. Powering those EVs will require a great deal of investment and infrastructure. McKinsey estimates that the United States will need some \$11 billion of capital investment by 2030 to deploy the 13 million chargers needed for all of the country's EVs.<sup>2</sup> Fleet EVs alone would consume up to 230 terawatt-hours of power per year, which would be approximately 6 percent of current US power generation. Their batteries would offer roughly 30 gigawatt-hours of electricity-storage capacity, or 15 to 20 percent of projected capacity in 2030.

Mass deployment of EV charging infrastructure will bring opportunities to run that equipment more efficiently and cost effectively. Our estimates indicate that services to support the charging of EV fleets could be worth some \$15 billion in annual revenues and cost savings. Much of that money would come from three activities (exhibit).<sup>3</sup>

- **Procuring renewable power directly from the source.** Purchasing electricity directly from off-grid generation facilities, rather than the power grid, could yield \$8.6 billion in cost savings, thanks to the difference between retail and wholesale energy prices (without accounting for avoided demand charges, which we discuss below). Our analysis suggests that in many geographies, the least expensive form of off-grid power would be solar, generated from onsite installations or purchased under direct contracts with large-scale installations.
- **Offering energy-management services.** Commercial-scale batteries would let fleet operators buy power during off-peak hours and use the stored power to recharge EVs when

<sup>1</sup> Estimates based on urban and regional use cases for commercial fleet vehicles.

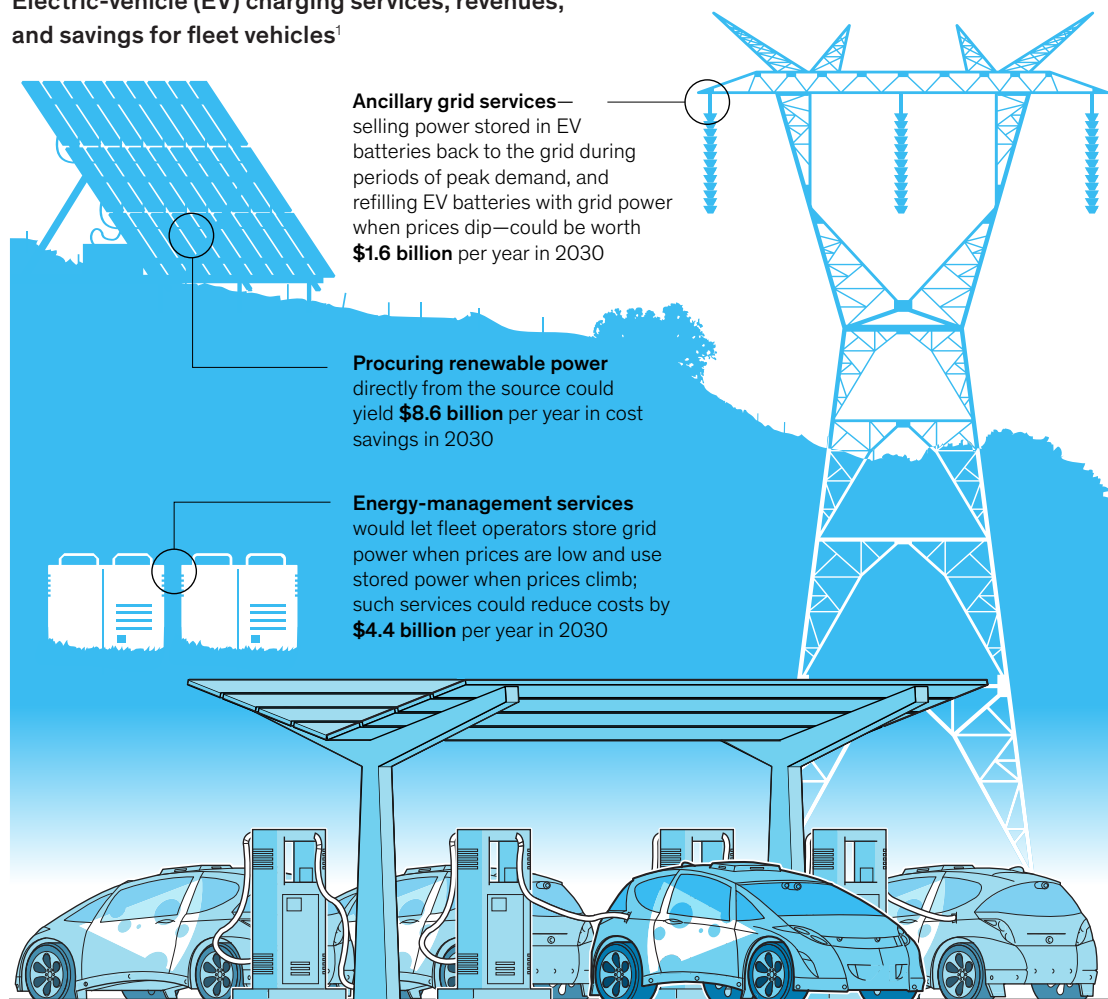
<sup>2</sup> Hauke Engel, Russell Hensley, Stefan Knupfer, and Shivika Sahdev, "Charging ahead: Electric-vehicle infrastructure demand," August 2018, McKinsey.com.

<sup>3</sup> The projected cost reductions and revenue gains are based on the electric-vehicle-fleet-size projections presented in the article, along with projected renewable-power prices and demand charges to 2030. These do not account for the potential prices of fleet-charging services or the costs to deliver them, only for the differences between retail and wholesale energy prices, for the differences between peak and off-peak energy prices, and for avoided demand fees. Projections of the amounts of electric power that US-based electric-vehicle fleets will purchase directly from renewable sources and from the grid are based on an assumption that fleet operators will use the least expensive energy sources available (taking demand charges into account) in each region. Projections also assume that no major shifts in policy will affect the relative costs of directly purchased renewable power and grid power.

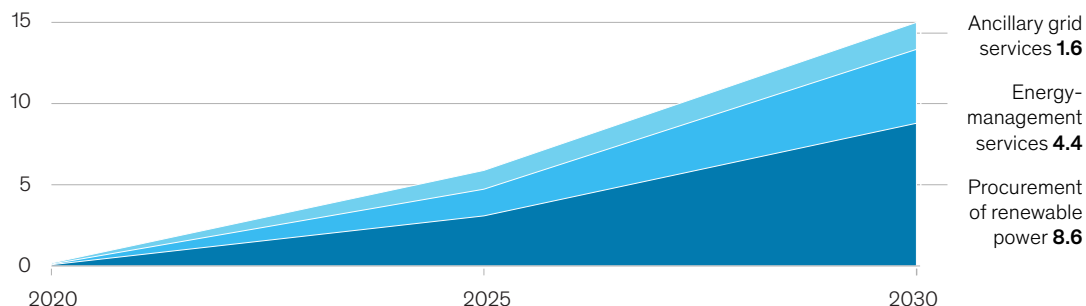
Exhibit

**By 2030, the US market for services to support the charging of electric-vehicle fleets could be worth \$15 billion.**

**Electric-vehicle (EV) charging services, revenues, and savings for fleet vehicles<sup>1</sup>**



**Combined revenues and cost savings by type, \$ billion<sup>1</sup>**



<sup>1</sup>The cost savings and revenue gains shown relate only to charging services for electric-vehicle (EV) fleets, not to sales of charging infrastructure or electric power used by fleet vehicles. The projected cost reductions and revenue gains are based on the EV-fleet-size projections presented in the article, along with projected renewable-power prices and demand charges to 2030. These do not account for the potential prices of fleet-charging services or the costs to deliver them, only for the differences between retail and wholesale energy prices, for the differences between peak and off-peak energy prices, and for avoided demand fees. Projections of the amounts of electric power that US-based EV fleets will purchase directly from renewable sources and from the grid are based on an assumption that fleet operators will use the least expensive energy sources available (taking demand charges into account) in each region. Projections also assume that no major shifts in policy will affect the relative costs of directly purchased renewable power and grid power.

electricity prices are highest. Practicing time-of-use arbitrage in this way could produce cost savings of roughly \$4.4 billion.

- **Providing ancillary grid services.** Selling power stored in EV batteries back to the grid during periods of peak demand, which is a form of “vehicle to grid” (V2G) service, not only lessens maximum loads on the grid but also allows EV owners to capitalize on high electricity prices. Similarly, charging stations can be configured to refill EV batteries with grid power when prices dip. Doing this helps vehicle owners avoid demand charges (additional fees, levied according to the maximum rate at which power is drawn), which can make up about 90 percent of a charging station’s electric bill.<sup>4</sup> Fleets with lower vehicle utilization and reliable charging patterns would be particularly suitable for V2G services. School buses, for example, have predictably low utilization during hours when power demand peaks. Setting EV-recharging patterns to deliver V2G services and minimize demand charges could generate \$1.6 billion in cost savings and revenues.

We believe that opportunities in EV fleet charging will materialize first in places with high-demand charges and sunny weather, which makes solar-power generation more economical. A favorable policy environment is important, too. Just as policies have aided the growth of the US market for EVs, they could also help the EV fleet-charging market to develop. No fewer than 15 states and territories offer incentives and tax credits for the installation of EV charging stations. (One reason for policy makers to support the development of the fleet-charging sector is that optimized fleet charging could also bring about other outcomes, such as reduced use of energy-intensive thermal “peaker” plants, expansion of renewable-generation capacity, and lower emissions of greenhouse gases and air pollutants.)

## Capturing opportunities in EV fleet charging

We believe that companies can best capture the opportunities in the EV fleet-charging market by offering a well-rounded set of services. To do this, four elements will need to be in place:

- **Hardware and software integration**, which helps fleet operators optimize energy and vehicle use by setting driving schedules and routes, charging intervals, and vehicle maintenance in alignment with customer demand, power prices, traffic conditions, and charging-station availability. Such solutions may need to be customized or developed.
- **Digital, analytics, and connectivity** supporting activities across the value chain, from data management to customer communications.
- **A large base of installed EV chargers** running at high utilization rates.
- **Access to price signals** from the power market, which can help optimize charging by enabling real-time decisions and avoiding peaker-plant energy generation.

Several kinds of companies have begun offering EV fleet-charging services, though they have yet to develop all of the capabilities described above. Solar-power companies have ventured into the business, generally with solutions that target individual vehicle owners rather than fleet operators. A segment of solar companies, solar carport providers, serves commercial and municipal fleets. But few of those offer substantial storage capacity, and their off-grid systems carry high balance-of-system costs (required costs related to hardware, software, and services other than the solar panel or battery).

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<sup>4</sup> Stefan Knupfer, Jesse Noffsinger, and Shivika Sahdev, “How battery storage can help charge the electric-vehicle market,” February 2018, McKinsey.com.



Utility companies manage most customer touchpoints and data, so they are well positioned to market new offerings. However, in the United States, about 60 percent of US power demand is found in competitive generation markets, where offering integrated charging services is difficult because power producers and distribution utilities must be separate companies. Makers of EV charging equipment are moving further downstream into energy management and operations, but few of

them generate power. Nor do providers of energy-management services.

Companies that wish to provide EV fleet operators with charging services will need to look beyond existing business models. It may require an investor or a well-capitalized business to combine multiple entities into one with all the right capabilities, or complementary businesses to join forces in a partnership.

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