McKinsey & Company

Report

The net-zero transition

What it would cost, what it could bring

McKinsey Global Institute
in collaboration with
McKinsey Sustainability and
McKinsey's Global Energy &
Materials and Advanced
Industries Practices

January 2022

McKinsey Global Institute

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In collaboration with McKinsey Sustainability and the Global Energy & Materials and Advanced Industries practices

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Preface

More than 10,000 years of continuous and accelerating progress have brought human civilization to the point of threatening the very condition that made that progress possible: the stability of the earth's climate. The physical manifestations of a changing climate are increasingly visible across the globe, as are their socioeconomic impacts. Both will continue to grow, most likely in a nonlinear way, until the world transitions to a net-zero economy, and unless it adapts to a changing climate in the meantime. No wonder, then, that an ever-greater number of governments and companies are committing to accelerate climate action.

At present, though, the net-zero equation remains unsolved: greenhouse gas emissions continue unabated and are not counterbalanced by removals, nor is the world prepared to complete the net-zero transition. Indeed, even if all net-zero commitments and national climate pledges were fulfilled, research suggests that warming would not be held to 1.5°C above preindustrial levels, increasing the odds of initiating the most catastrophic impacts of climate change, including the risk of biotic feedback loops. Moreover, most of these commitments have yet to be backed by detailed plans or executed. Nor would execution be easy: solving the net-zero equation cannot be divorced from pursuing economic development and inclusive growth. It would require a careful balancing of the shorter-term risks of poorly prepared or uncoordinated action with the longer-term risks of insufficient or delayed action. Indeed, a more disorderly transition could impair energy supply and affect energy access and affordability, especially for lower-income households and regions. It could also have knock-on impacts on the economy more broadly, potentially creating a backlash that would slow down the transition.

None of these challenges should come as a surprise. Achieving net zero would mean a fundamental transformation of the world economy, as it would require significant changes to the seven energy and land-use systems that produce the world's emissions: power, industry, mobility, buildings, agriculture, forestry and other land use, and waste. To bring about these changes, nine key requirements (encompassing physical building blocks, economic and societal adjustments, and governance, institutions, and commitment) would need to be fulfilled against the backdrop of many economic and political challenges.

This means addressing dozens of complex questions, including: what is the appropriate mix of technologies that need to be deployed to achieve emissions reductions while staying within a carbon budget, limiting costs, and delivering required standards of performance? Where are supply chain and infrastructure bottlenecks most likely to occur? Where might physical constraints, whether related to the availability of natural resources or the scale-up of production capacity, limit the pace of the transition? What levels of spending on physical assets would the transition require? Who would pay for the transition? How would the transition affect companies' markets and operations? What would it spell for workers and consumers? What opportunities and risks would it create for companies and countries? And how could consumers be encouraged to make changes to consumption and spending habits that will be necessary to ensure the transition?

In this report, we attempt to answer some of these questions, namely, those pertaining to the economic and societal adjustments. We provide estimates of the economic changes that would take place in a net-zero transition consistent with 1.5°C of warming. We seek to build and expand upon the vast external literature on the net-zero transition, in order to offer a more detailed and granular view of the nature and magnitude of the economic changes that it would entail. As a result, our estimates of the annual spending on physical assets for a net-zero transition exceed to a meaningful degree the $3 trillion–$4.5 trillion total spending estimates that previous analyses have produced.

This report is a first-order analysis of a hypothetical 1.5°C scenario. As such, it has several limitations.

First, it is not clear whether a 1.5°C scenario is achievable in the first place, nor what pathway the world would take to achieve it if it were. Indeed, some believe that 1.5°C is already out of reach, given the current trajectory of emissions and their potential to activate climatic feedback loops, as well as prevailing challenges with revamping energy and land-use systems. This research does not take a position on such questions. Instead, it seeks to demonstrate the economic shifts that would need to take place if the goal of 1.5 degrees is to be attained through a relatively orderly transition between now and 2050.

Second, this report is by nature and necessity limited in its scope. In particular it does not focus on such issues as technology breakthroughs, physical constraints related to scale-up capacity and the availability of natural resources, delayed-transition costs, the role of adaptation, or other imponderables or uncertainties, nor have we yet modeled the full range of economic outcomes likely under a net-zero transition. As a result, it is likely that real outcomes will diverge from these estimates, particularly if the net-zero transition takes a more disorderly path or restricting warming to 1.5°C proves unachievable. Spending requirements could be higher, for example due to the additional investment needed to maintain flexibility and redundancy in energy systems, or heightened physical risks and commensurate adaptation costs.

Third, this report does not explore the critical question of who pays for the transition. What is clear is that the transition will require collective and global action, particularly as the burdens of the transition would not be evenly felt. The prevailing notion of enlightened self-interest alone is unlikely to be sufficient to help achieve net zero, and the transition would challenge traditional orthodoxies and require unity, resolve, and ingenuity from leaders.

We nonetheless hope that our scenario-based analysis will help decision makers refine their understanding of the nature and the magnitude of the changes the net-zero transition would entail and the scale of response needed to manage it. We also hope that our attempts to describe as accurately as we can the challenges that lie ahead are seen as what they are: a call for more thoughtful and more decisive action, urgency, and resolve.

The report is joint research by McKinsey Sustainability, McKinsey's Global Energy and Materials Practice, McKinsey's Advanced Industries Practice, and the McKinsey Global Institute. McKinsey has long focused on issues of environmental sustainability, dating to client studies in the early 1970s. We developed our global greenhouse gas abatement cost curve in 2007, updated it in 2009, and have since conducted national abatement studies in countries including Brazil, China, Germany, India, Russia, Sweden, the United Kingdom, and the United States. Recent research on which we build in this publication includes the January 2020 report *Climate risk and response: Physical hazards and socioeconomic impacts,* a January 2021 article, "Climate math: What it takes to limit warming to 1.5°C," and two October 2021 articles, "Our future lives and livelihoods: Sustainable and inclusive and growing" and "Solving the net-zero equation: Nine requirements for a more orderly transition."

This research was led by Mekala Krishnan, a McKinsey Global Institute (MGI) partner in Boston; Hamid Samandari, a McKinsey senior partner in New York; Jonathan Woetzel, a senior partner and MGI director in Shanghai; Sven Smit, a senior partner in Amsterdam and co-chair of MGI; Daniel Pacthod, a senior partner in New York; Dickon Pinner, a senior partner in San Francisco; Tomas Nauclér, a senior partner in Stockholm; and Humayun Tai, a senior partner in New York. The research team was led in different periods by Annabel Farr, Danielle Imperato, Johanneke Tummers, Sophie Underwood, and Weige Wu. Team members: Wouter van Aanholt, Rishi Arora, Carolyne Barker, Ryan Barrett, Anna Benkeser, Mélanie Bru, Gene Chang, Jonas DeMuri-Siliunas, William Désilets, Julia Dhert, Spencer Dowling, William Edwards-Mizel, Karina Gerstenchlager, Jakob Graabak, Chantal de Graaf, Pragun Harjai, Laura Hofstee, Jania Kesarwani, Dhiraj Kumar, Joh Hann Lee, Youting Lee, Diego Miranda, Ian Murphy, Prit Ranjan, Shresth Sanghai, Lex Razoux Schultz, Ruben Robles, Kevin Russell, Nick Thiros, Ben D. Thomas, Sarah Vargese, Colin Varn, and Jan-Paul Wiringa.

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This report contributes to our mission to help business and policy leaders understand the forces transforming the global economy. As with all MGI research, it is independent and has not been commissioned or sponsored in any way by any business, government, or other institution.

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In brief

The net-zero transition: What it would cost, what it could bring

Governments and companies are increasingly committing to climate action. Yet significant challenges stand in the way, not least the scale of economic transformation that a net-zero transition would entail and the difficulty of balancing the substantial short-term risks of poorly prepared or uncoordinated action with the longer-term risks of insufficient or delayed action. In this report, we estimate the transition's economic effects on demand, capital allocation, costs, and jobs to 2050 globally across energy and land-use systems that produce about 85 percent of overall emissions and assess economic shifts for 69 countries. Our analysis is not a projection or a prediction and does not claim to be exhaustive; it is the simulation of one hypothetical, relatively orderly path toward 1.5°C using the Net Zero 2050 scenario from the Network for Greening the Financial System (NGFS), to provide an order-of-magnitude estimate of the economic transformation and societal adjustments associated with net-zero transition. We find that the transition would be universal, significant, and front-loaded, with uneven effects on sectors, geographies, and communities, even as it creates growth opportunities:

Capital spending on physical assets for energy and land-use systems in the net-zero transition between 2021 and 2050 would amount to about $275 trillion, or $9.2 trillion per year on average, an annual increase of as much as $3.5 trillion from today. To put this increase in comparative terms, the $3.5 trillion is approximately equivalent, in 2020, to half of global corporate profits, one-quarter of total tax revenue, and 7 percent of household spending. An additional $1 trillion of today's annual spend would, moreover, need to be reallocated from high-emissions to low-emissions assets. Accounting for expected increases in spending, as incomes and populations grow, as well as for currently legislated transition policies, the required increase in spending would be lower, but still about $1 trillion. The spending would be front-loaded, rising from 6.8 percent of GDP today to as much as 8.8 percent of GDP between 2026 and 2030 before falling. While these spending requirements are large and financing has yet to be established, many investments have positive return profiles (even independent of their role in avoiding rising physical risks) and should not be seen as merely costs. Technological innovation could reduce capital costs for net-zero technologies faster than expected.

In this scenario, the global average delivered cost of electricity would increase in the near term but then fall back from that peak, although this would vary across regions. As the power sector builds renewables and transmission and distribution capacity, the fully loaded unit cost of electricity production, accounting for operating costs, capital costs, and depreciation of new and existing assets, in this scenario could rise about 25 percent from 2020 until 2040 and still be about 20 percent higher in 2050 on average globally. Cost increases in the near term could be significantly higher than those estimated here, for example, if grid intermittency issues are not well managed. The delivered cost could also fall below 2020 levels over time because of the lower operating cost of renewables—provided that power producers build flexible, reliable, and low-cost grids.

The transition could result in a gain of about 200 million and a loss of about 185 million direct and indirect jobs globally by 2050. This includes demand for jobs in operations and in construction of physical assets. Demand for jobs in the fossil fuel extraction and production and fossil-based power sectors could be reduced by about nine million and four million direct jobs, respectively, as a result of the transition, while demand for about eight million direct jobs would be created in renewable power, hydrogen, and biofuels by 2050. While important, the scale of workforce reallocation may be smaller than that from other trends including automation. Displaced workers will nonetheless need support, training, and reskilling through the transition.

While the transition would create opportunities, sectors with high-emissions products or operations—which generate about 20 percent of global GDP—would face substantial effects on demand, production costs, and employment. In the NGFS Net Zero 2050 scenario, coal production for energy use would nearly end by 2050, and oil and gas production volumes would be about 55 percent and 70 percent lower, respectively, than today. Process changes would increase production costs in other sectors, with steel and cement facing increases by 2050 of about 30 and 45 percent, respectively, in the scenario modeled here. Conversely, some markets for low-carbon products and support services would expand. For example, demand for electricity in 2050 could more than double from today.

Poorer countries and those reliant on fossil fuels are most exposed to the shifts in a net-zero transition, although they have growth prospects as well. These countries are more susceptible to changes in output, capital stock, and employment because exposed sectors make up relatively large parts of their economies. Exposed geographies including in sub-Saharan Africa and India would need to invest 1.5 times or more than advanced economies as a share of GDP today to support economic development and build low-carbon infrastructure. The effects within developed economies could be uneven, too; for instance, more than 10 percent of jobs in 44 US counties are in fossil fuel extraction and refining, fossil fuel–based power, and automotive manufacturing. At the same time, all countries will have growth prospects, from endowments of natural capital such as sunshine and forests, and through their technological and human resources.

Consumers may face additional up-front capital costs and have to spend more in the near term on electricity if cost increases are passed through, and lower-income households everywhere are naturally more at risk. Consumer spending habits may also be affected by decarbonization efforts, including the need to replace goods that burn fossil fuel, like transportation vehicles and home heating systems, and potentially modify diets to reduce high-emissions products like beef and lamb. The up-front capital spending for the net-zero transition could yield lower operating costs over time for consumers. For example, total cost of ownership for EVs is expected to be lower than ICE cars in most regions by 2025.

Economic shifts could be substantially higher under a disorderly transition, in particular because of higher-order effects not considered here. The economic and social costs of a delayed or abrupt transition would raise the risk of asset stranding, worker dislocations, and a backlash that delays the transition. Even under a relatively gradual transition, if the ramp-down of high-emissions activities is not carefully managed in parallel with the ramp-up of low-emissions ones, supply may not be able to scale up sufficiently, making shortages and price increases or volatility a feature. Much therefore depends on how the transition is managed.

For all the accompanying costs and risks, the economic adjustments needed to reach net zero would come with opportunities and prevent further buildup of physical risks. Incremental capital spending on physical assets creates growth opportunities, in connection with new low-emissions products, support services, and their supply chains. Most importantly, reaching net-zero emissions and limiting warming to 1.5°C would reduce the odds of initiating the most catastrophic impacts of climate change, including limiting the risk of biotic feedback loops and preserving our ability to halt additional warming.

Government and business would need to act together with singular unity, resolve, and ingenuity, and extend their planning and investment horizons even as they take immediate actions to manage risks and capture opportunities. Businesses would need to define, execute, and evolve decarbonization and offsetting plans for scope 1 and 2 emissions and potentially expand those plans to include scope 3 emissions, depending on the nature of their operations, and the materiality, feasibility, and need of doing so. Over time, they would need to adjust their business models as conditions change and opportunities arise; integrate climate-related factors into decision-making processes for strategy, finance, and capital planning, among others; and consider leading action with others in their industry or ecosystem of investors, supply chains, customers, and regulators. Financial institutions in particular have a pivotal role to play in supporting large-scale capital reallocation, even as they manage their own risks and opportunities. Governments and multilateral institutions could use existing and new policy, regulatory, and fiscal tools to establish incentives, support vulnerable stakeholders, and foster collective action. The pace and scale of the transition mean that many of today's institutions would need to be revamped and new ones created to disseminate best practices, establish standards and tracking mechanisms, drive capital deployment at scale, manage uneven impacts, and support further coordination of efforts.

The goal of this research is to provide stakeholders with an in-depth understanding of the nature and magnitude of the economic and societal adjustments a net zero transition would entail. Our hope is that this analysis provides leaders with the tools to collectively secure a more orderly transition to net-zero by 2050. The findings serve as a clear call for more thoughtful and decisive action, taken with the utmost urgency. The rewards of the net-zero transition would far exceed the mere avoidance of the substantial, and possibly catastrophic, dislocations that would result from unabated climate change, or the considerable benefits they entail in natural capital conservation. Besides the immediate economic opportunities they create, they open up clear possibilities to solve global challenges in both physical and governance-related terms. These include the potential for a long-term decline in energy costs that would help solve many other resource issues and lead to a palpably more prosperous global economy. More importantly, they presage decisive solutions to age-old global economic and political challenges as the result of the unprecedented pace and scale of global collaboration that such a transition would have required. And while the immediate tasks ahead may seem daunting, human ingenuity can ultimately solve the net-zero equation, just as it has solved other seemingly intractable problems over the past 10,000 years. The key issue is whether the world can muster the requisite boldness and resolve to broaden its response during the upcoming decade that will in all likelihood decide the nature of the transition.