

PREPARING FOR A WARMER WORLD

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This article is the second in a series on the future of energy in an increasingly uncertain world.

THE WORLD HAS THE means to achieve the goal set out in the Paris climate accord—but the odds of doing so are long. Governments, organizations, and individuals should still double down on efforts to limit global warming, but at the same time, we all must plan for a hotter planet.

According to the consensus among climatologists, the upward trajectory of greenhouse gas emissions needs to be reversed by 2025 to hit the Paris target: to limit the global temperature increase by 2100 to well below 2°C higher than pre-industrial (late-19th-century) levels.

Technologies—including renewables, energy efficiency measures, and substitution of energy sources—are available to reverse the growth in emissions. But they must be deployed at scale, and doing so would require fast, forceful, and united action by governments and regulators worldwide, using all

the levers at their disposal—well beyond current efforts. It would also call for a huge upfront investment: \$19 trillion to \$21 trillion from now until 2030, according to our estimates. Both requirements may be difficult to achieve in the scarce time we have left.

Economic disparities among countries are a large part of the problem. Our research confirms that even if China, the European Union, developed countries in Asia, and the US curbed their emissions, the Paris target would still be out of reach. Non-OECD emerging economies would also need to do the same. Yet although the investment required to implement the technologies would be manageable for rich OECD countries and China, most emerging economies, which would need to make a substantial part of the investment, would not be able to afford it on their own.

Climate scientists do not know for sure how warm the world will become or how quickly. While it is imperative that we don't ease up on actions to curb climate change, companies, governments, and

investors need to wake up to the likelihood of a hotter planet and factor that into their assumptions about the future.

The Scale of the Challenge

For our purposes, we have divided the world into three parts: rich countries from the OECD and developed countries in Asia; China, which has emerged as an economic powerhouse in its own right; and the rest of the world, mainly consisting of less affluent non-OECD countries, which we call “emerging economies” throughout this article.

To meet the Paris target, climatologists contend that manmade emissions would need to fall in the first half of the next decade and then decline steeply such that, by 2040, the global population would produce about half the emissions that it does today. Through efficiency measures, global economic activity would have to be far less energy intensive, and energy usage would need to emit much less carbon. We would need to take aggressive action on all possible fronts to achieve this goal. Even in the event of slow global economic growth, the task would be daunting.

To enable the sharp decline in fossil fuel consumption that is required, global power generation—which accounts for a quarter of anthropogenic emissions—would have to emit at least 70% less carbon dioxide by 2040 (en route to full decarbonation). This implies a steep decrease in coal power generation and far greater deployment of wind and solar power. At the same time, significant progress toward decarbonation would need to be made in the transportation, agriculture, industrial, and building sectors. We would need to increase substantially, and at a global scale, the energy efficiency of our buildings, electrical appliances and lights, and conventional internal combustion engines. Electric vehicles would also need to be broadly deployed.

Technology on Its Own Won't Be Enough

Reversing the trajectory of global emissions will require radical changes to the

global energy mix, but the technologies are available. Insulation, LED lighting, efficient appliances, low-fuel-consumption engines, electric mobility, and self-driving vehicles are starting to create a more energy-efficient world. Moreover, renewable wind and solar power (helped by rapidly declining costs and improved storage technologies) and the shift from coal in power generation and from oil to gas in refineries and heavy transport are reducing the carbon intensity of economic activity.

However, we cannot count on all of these advances to become competitive with conventional technologies in time to achieve the Paris target. For example, solar and wind energy have, through cost reductions, become cheaper than conventional sources—when there is sun or wind. Their intermittent nature means that the cost of these unconventional sources, and of static batteries, will have to continue declining if solar and wind are to pay for the backup storage technologies required and if they are to become competitive on a year-round basis. Regulators and governments around the world would need to act to ensure the widespread adoption of the technologies at scale and in time. Because the environment is a public good, it's only right that protecting it requires policies that enforce correct behaviors.

One Obstacle to Achieving the Paris Goal

Although China is encouraging a domestic renewables industry and is taking dramatic steps to address urban pollution and climate issues, fossil fuel dependence in emerging economies is a significant obstacle to achieving the Paris ambitions. Population growth and energy-intensive economic activity—in power generation, industry, transport, and agriculture—in already densely populated emerging economies are key drivers of rising anthropogenic emissions.

Emerging economies currently account for more than one-third of the world's fossil fuel power-generating capacity, and their share is set to exceed 45% by 2040. In

South American and Asian emerging countries, deforestation (often to make way for beef cattle, which produce methane from enteric digestion) is an important contributor to the 15% of global greenhouse gas emissions from forestry and agriculture.

Emerging countries have a desire and a right to catch up with their wealthier counterparts. But whereas rich OECD nations can invest in energy efficiency measures, that’s not the case in many emerging economies, where economic activity remains energy intensive because of aging factories and traditional manufacturing operations. In addition, the majority of the world’s population growth will be in emerging economies in Africa and Asia.

Using BCG’s Global Energy Scenario Model, we developed a “business as usual” scenario, which assumes the fulfillment of policy commitments to date and continuing progress in energy efficiency. On the basis of that scenario, we estimate that emerging economies will account for more than 130% of the increase in global fossil fuel demand between 2015 and 2040, equivalent to 7 billion tons of carbon dioxide per year, while OECD countries and China will see a dip in demand.

Although rich countries are the main source of the emissions that have warmed global temperatures to current levels, emerging countries account for the fastest

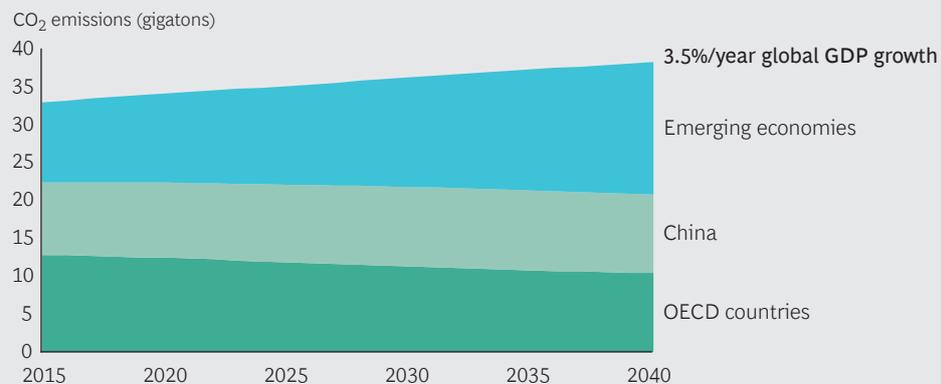
growth in emissions and would therefore need to be part of any solution for meeting the Paris target. (See Exhibit 1.) Without the means to pay for the necessary technologies, however, they will be hard pressed to do this.

A Global Effort

Using our model, we then assumed modest real global GDP growth of 3% per year from 2015 to 2040—slower than the growth rate of up to 3.5% many institutions anticipate over this period. We also assumed that governments continued with their current policies for transitioning to a low-carbon economy. Taking these steps stabilized the amount of greenhouse gas emissions in the atmosphere and reduced the volume that would need to be removed to achieve a trajectory of 2°C.

We then assumed that both rich OECD countries and China took very aggressive action—well beyond their current policies—to cut their emissions, including energy efficiency measures, significant adoption of renewables and electric vehicles, substitution wherever possible of oil by gas in petrochemicals and heavy transport, and a faster retirement of coal-fired power plants. This reduced the volume of emissions that would need to be removed between 2015 and 2040 by about half. The remaining amount would have to be addressed with equally aggressive and ex-

EXHIBIT 1 | Emerging Economies Will Drive Emissions Growth



Source: BCG Global Energy Scenario Model.

Note: This scenario is based on the fulfillment of policy commitments to date and continuing progress in energy efficiency.

haustive action by emerging economies to curb their own emissions. (See Exhibit 2.)

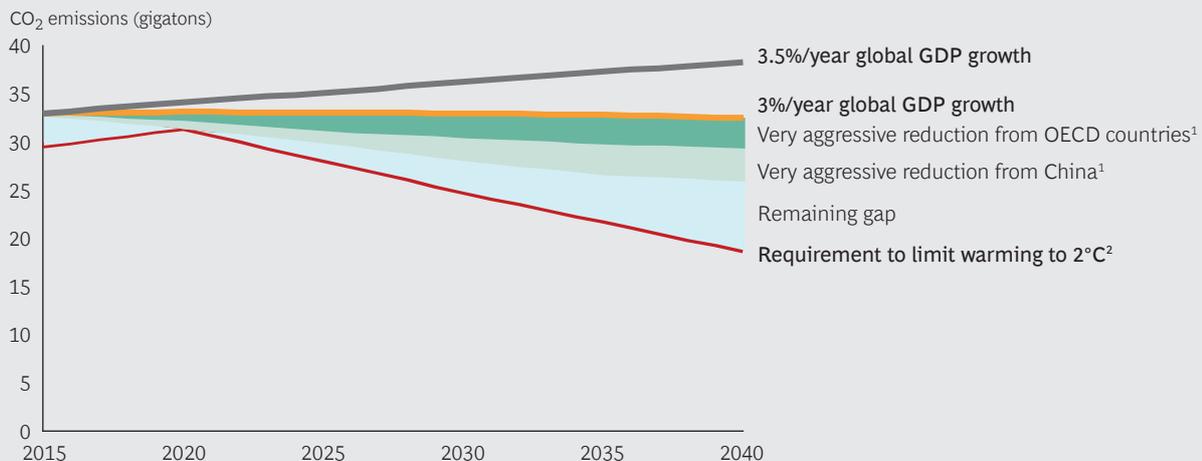
In the absence of unified global action, countries that pursue a low-carbon agenda unilaterally would face a first-mover disadvantage—in short, the benefits of their investment would pay off only if all other countries did the same, and at a similar pace. Certainly, wealthier countries, in addition to regulating to promote energy efficiency and lower carbon usage by their own citizens and corporations, should show leadership through a combination of policies and support aimed at changing behaviors around the world.

Indeed, a global approach might persuade governments in rich countries to help poor nations with the technology bill. Wealthier governments could also take regulatory action to curb emissions in their companies’ supply chains, which often span developed and emerging countries. Regardless, without financial assistance and appropriate incentives, the investment required remains a significant obstacle for the poorest countries.

The \$19 trillion to \$21 trillion that would need to be invested from now until 2030 would cover the deployment of technologies and energy efficiency measures at scale, and the replacement of conventional polluting assets. Between 60% and 80% of this sum would fall on emerging economies. This upfront investment would be very large for governments and the private sector. It would largely be paid back, though over many years, through lower fuel, labor, and maintenance costs.

Despite this, most emerging economies cannot afford to stop using their fossil-fuel-fired power plants, cease building new ones, or make a huge investment in zero- and low-carbon technologies. In emerging countries, most power plants are coal-fired and are less than ten years old, far younger than in the OECD, where coal plants are typically at least 30 years old. Achieving the step change in the global energy landscape necessary to hit the Paris target would require the “accelerated mortality” of the world’s conventional power generation assets. But such a move would hit emerging economies hardest because of

EXHIBIT 2 | Limiting Global Warming Requires Fast, Radical, and Global Action



Source: BCG Global Energy Scenario Model.

¹Assumes ICE efficiency of LDVs of 4.3l/100km in OECD and 6.3l/100km in non-OECD by 2040; 14l/100km and 23l/100km, respectively, for HDVs; 90% EV share in OECD and China by 2040, in emerging economies by 2050; 27% efficiency increase of buildings; 90% to 100% LED lighting in OECD and emerging economies, 100% clean cooking, increased efficiency of appliances; biofuels in HDVs reach 30% to 50%, in aviation 50%, in shipping 20%; 60% of technically potential decentralized solar PV deployed; wind and solar PV replaces fossil fuel capacity additions (30% to 60% in OECD, 15% to 50% in emerging economies); power-to-heat: 80% of new builds, 75% to 50% of refurbishments have heat pumps in OECD and China; high replacement of oil by gas (in petrochemicals: oil share 20% in North America and Middle East, 35% in China; gas share in trucks 70% in OECD Americas, 60% in China, 20% in Europe, Asia, Latin America; gas share in power, industry, and buildings reaches US level in China and Argentina due to shale gas); high replacement of coal (OECD and China stop building new coal plants as of 2015, retire all plants >40 years as of 2020 and all plants >35 years as of 2030; emerging economies stop building new plants as of 2025 and retire all plants >40 years as of 2030).

²Assumes an initial increase in emissions.

their lower GDPs and the age of their assets.

We estimate that OECD countries and China would have to invest 0.9% and 1.2% of their annual GDP, respectively, in these technologies from now until 2030 to achieve the Paris target. For emerging countries, the investment required over the same period would be 1.4% to 1.5% of annual GDP. For these countries—faced with the pressure to invest in essential infrastructure, improve public health, and provide citizens with food and other basic amenities—this amount is beyond their means. And the populations of these countries would not accept the tradeoffs that would be required.

What This Means for Governments, Business, and All of Us

Our view risks placing us in the crossfire of an emotionally charged debate. We don't know for sure the impact that progressively higher temperatures will have on the environment. According to some scientific studies, the world could face a growing risk of famine with a rise of more than 3°C and a higher probability that major cities would be devastated by rising sea levels with an increase of more than 4°C. The science behind this analysis is hugely complex; we may have more leeway than this, or less. Even so, we cannot take the chance of getting it catastrophically wrong because of our failure to act. The probability of these events may be low, but the risk is not worth taking.

Governments, companies, and individuals should step up their actions to limit climate change in the following ways:

- **Double down and build global coalitions.** Governments need to double down on efforts to curb greenhouse gas emissions. Not doing so would significantly increase the risk of an uncontrollable rise in global temperatures. By creating global coalitions, leading governments can build a consensus for change and avoid the dangers of institutional inertia and first-mover disadvan-

tage that are likely to affect poor economies more than wealthy ones—while regulating to encourage changes in behaviors across the planet.

- **Make high-impact moves.** Governments must increase the effectiveness of existing environmental policies and measures even as they push ahead with larger global goals, such as an international carbon-pricing scheme. Rather than taking a carpet-bomb approach to solutions, they should focus on the measures that will have the greatest impact, such as promoting energy efficiency and deploying solar panels and wind farms in regions where they can be most effective. Similarly, a global carbon scheme that imposes different levels of tax for individual countries or regions is likely to produce the best outcome and mitigate the issue of affordability.
- **Invest heavily in proven technologies.** Individuals and institutions should invest with the crowd when it comes to emission reduction technologies: the window of opportunity for entirely new environmental technologies is closing. Given the need for effective technologies that can be broadly deployed in the near term, existing technologies, many of which are quickly becoming cheaper and more efficient, are likely to beat newcomers. Investing in any new or nascent technologies will make sense only if these have the potential to have a massive impact on emission reduction. Technologies that could in theory be game-changers, such as carbon capture and storage, hydrogen, or nuclear fusion, seem unlikely to be both workable and scalable soon enough.
- **Explore mitigation approaches.** Governments and companies should start investing in technologies that could reduce existing greenhouse gases or mitigate their effects on a global scale: for example, the large-scale removal of carbon dioxide from the atmosphere through initiatives such as global tree planting or the use of

geo-engineering interventions to limit further temperature increases despite high carbon dioxide concentrations. Geo-engineering solutions, once proven, are likely to span national borders and so will require a globally coordinated effort. They wouldn't address all the consequences of high carbon dioxide levels, such as acidic oceans, but would limit the most catastrophic effects.

In parallel, all players need to be pragmatic and consider how to prepare for a warmer world:

- **Face the risks and plan accordingly.** Even if aggressive action is taken to reduce carbon emissions, governments must accept that the world will become warmer and prepare for risks arising from this eventuality, such as rising sea levels and more turbulent weather patterns. Governments will need to prioritize spending on coastal barriers and other infrastructure defenses, and adjust urban development plans to limit population expansion into vulnerable areas. For regions that depend on agriculture, including much of Africa, investment will be required to improve soil management and water usage, and bolster climate forecasting and observation networks. Companies will need to build climate resilience by encouraging the conservation of natural resources in the supply chain and developing robust business continuity plans in the event of natural disaster. Some may need to relocate facilities.
- **Adjust energy business models and portfolios.** Energy companies across the spectrum will need to adapt their business models and portfolios for an increase in stranded assets, a rise in distributed power, and changes in how energy sources are used. The case they make to investors will need to evolve, with dramatic adjustments required in some instances. (For more on how the energy industry must adapt to a changing world, see the sidebar.)
- **Consider the climate in strategic planning.** Investors and companies in all industries will need to take climate change into account in their strategic planning. By anticipating the direction of regulations governing energy usage and the environment, they can ensure that their assets and activities are on the right side of future policy measures.
- **Invest to protect the business and develop new solutions.** Companies will also need to factor climate change into their investment decisions and protect business assets, safeguard supply chains, and mitigate commodity exposures. For some companies, such as those in certain extractive and agricultural industries or global companies with extensive supply chains in vulnerable areas, this could pose a huge problem. Rising sea levels and temperatures could wipe out businesses. But a warmer planet will also create the need for new solutions: for example, the shifting geographic footprint of various diseases will require different health care responses; a warmer environment will foster new types of agriculture; and scarcer water resources will call for innovations from water treatment providers.

DESPITE THE TECHNOLOGIES at our disposal, we will probably miss the Paris climate target. However, it remains an important yardstick. By striving to achieve it, we can take vital steps that will help limit climate change for our own and future generations. This will likely require a global commitment to support emerging countries with their transition to low-carbon economies. Nevertheless, we should also concede that the world will get warmer, and we must take steps to prepare for that eventuality.

PREPARING FOR THE FUTURE OF ENERGY IN AN UNCERTAIN WORLD

Participants across the energy industry are struggling to find their footing in a rapidly evolving landscape. The pace of change, and the disruption it brings, is set to accelerate before we reach a new equilibrium. And no one knows precisely what that will look like.

For decades, the industry had familiar contours: energy sources and markets operated in virtual silos, investment horizons were long, and technological development was steady but not disruptive. The uninterrupted growth of global demand for all sources—whether coal, oil, or natural gas—was taken as a given.

Now, all that is in flux. Rapid structural changes in energy markets—at times initiated by regulation but fundamentally driven by technological innovation—have intensified competition among both traditional and renewable sources. Disruptions that were unimaginable not long ago—such as the emergence of environmentally friendly electric vehicles and the substantial use of wind and solar energy in power generation—are now realities.

The myriad potential combinations of these disruptive factors and others would

lead to very different outcomes for energy companies and for countries.

But whatever the outcome, industry players will need to adapt. Companies must minimize the risk of stranded assets, manage complex resource exposures, and stay on the right side of upcoming regulations. Governments must ensure that the transition to cleaner energy is not overly costly for citizens and industry, and promote long-term technologies without generating windfall profits for a few.

Industry players and governments also face a higher-order challenge: given an uncertain world, they must develop the capability to examine the assumptions behind conflicting outlooks, assess the impact of various disruptions, individually and in combination, and prepare for the range of possible energy futures.

Companies and national authorities need to navigate strategic energy decisions and engage in a dialogue with stakeholders about solutions that will help make the energy transition as effective as possible while addressing environmental challenges.

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Acknowledgments

The authors thank Eric Boudier, Hans-Paul Bürkner, Philipp Gerbert, Tycho Möncks, Martin Reeves, Matthias Tauber, and Judith Wallenstein for their contributions to this article.

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