# Financing the Clean Industrial Revolution

**Why it's hard to build the net-zero economy—and how we can do it anyway**

BY BILL GATES

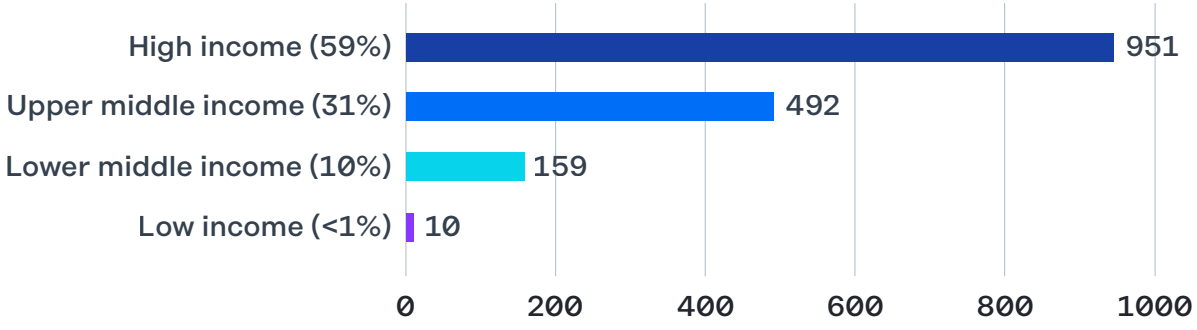
## INTRODUCTION

The recent Intergovernmental Panel on Climate Change (IPCC) report was sobering. But I still believe the world can avoid a climate disaster—if we reduce greenhouse gas emissions from roughly 51 billion tons per year to zero by 2050. Getting to zero will be the hardest thing people have ever done. Almost every human activity releases greenhouse gases, so we need to change the way we do almost everything—and do it in a single generation.

When I think about getting to zero, I imagine Brazil, India, South Africa, or any other emerging economy 25 years from now. The people in these countries will demand better access to electricity, convenient transportation, and a varied diet. The businesses and governments will build airports, apartment houses, factories, roads, and other infrastructure. This is good news. All people deserve a high standard of living. Many countries in Europe and North America filled the atmosphere with carbon to achieve theirs; it is unrealistic and unfair to expect everyone else to forego prosperity because carbon turns out to change the climate. The world cannot force billions of people to choose between their own aspirations and a livable climate. We need to invent technologies that can give all people the lives they strive for without emitting greenhouse gases.

### Cumulative Carbon Dioxide Emissions Over Time

Billion tons of $CO_2$ from 1751-2019



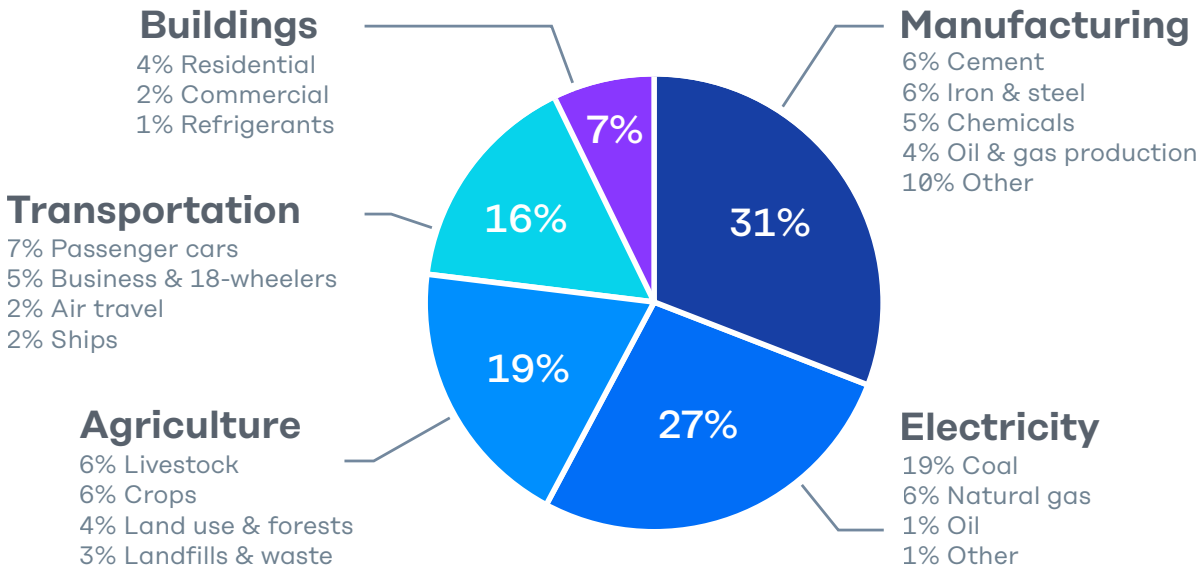

High-income and upper middle–income countries make up nearly 90% of cumulative global carbon dioxide emissions since the Industrial Revolution.

Source: Emissions from Our World in Data; Income classification from World Bank

Technological transitions like this happen when new technologies are manifestly better than the old ones. In the past, "better" has meant either more functionality or less cost. Today, most clean technologies promise neither. Although there are notable exceptions, most won't add functionality. Sustainable jet fuel does what jet fuel does, steel made using green hydrogen does what steel does, and so on. Furthermore, for at least the next decade or two, most clean technologies will cost more, not less, than their higher-emissions counterparts. I call that difference in the price the Green Premium.

I've written a lot about the Green Premium because I believe understanding the concept is the key to success. With some technologies, especially electric cars and solar and wind power, the Green Premium is now at, near, or even below zero. As a result, those technologies are taking off. But cars and electricity are not the only causes of climate change, and addressing many others remains prohibitively expensive. According to the International Energy Agency, half the technology needed to get to zero either doesn't exist yet or has a very high Green Premium that keeps it from being cost competitive.

## Global Sources of Greenhouse Gases




Source: Rhodium Group, 2017; % are rounded

So why am I optimistic we can get to zero? Because our values are starting to shift. In just the past few years, as people have awakened to the severity of climate change, consumers, employees, shareholders, and voters have started to add climate impact to their definition of "better," alongside functionality and price. People still won't pay twice as much for green cement—and if they have to, they might turn against climate action—but all other things being approximately equal, they are making it clear that cleaner is, for the first time ever, "better."

Governments and businesses are responding to these signals. According to a recent study, 124 of 202 countries and more than 400 of the 2,000 largest companies have made commitments to reach net zero emissions. It makes sense that governments are in the lead, since they exist explicitly to serve the public good. Increasingly, however, companies are also being judged—and are therefore judging themselves—according to their climate impact as well as their profitability.

These net-zero commitments are an important first step. But the next step, actually meeting the commitments, is just as important. Right now, hundreds of companies are busy planning how to spend billions of dollars to fulfill the promises they have made to reduce emissions. The new definition of "better"—and the money it will unlock—give the world a fighting chance to fit an energy transition that under ordinary circumstances would take 50 or 100 years into 25 years.

But having a chance and seizing it are two different things. Unfortunately, there are a lot of ways to spend money on climate change that won't get us to zero. The priority is to harness the world's burgeoning commitment to climate so that the investments and policies we get are the ones we need.

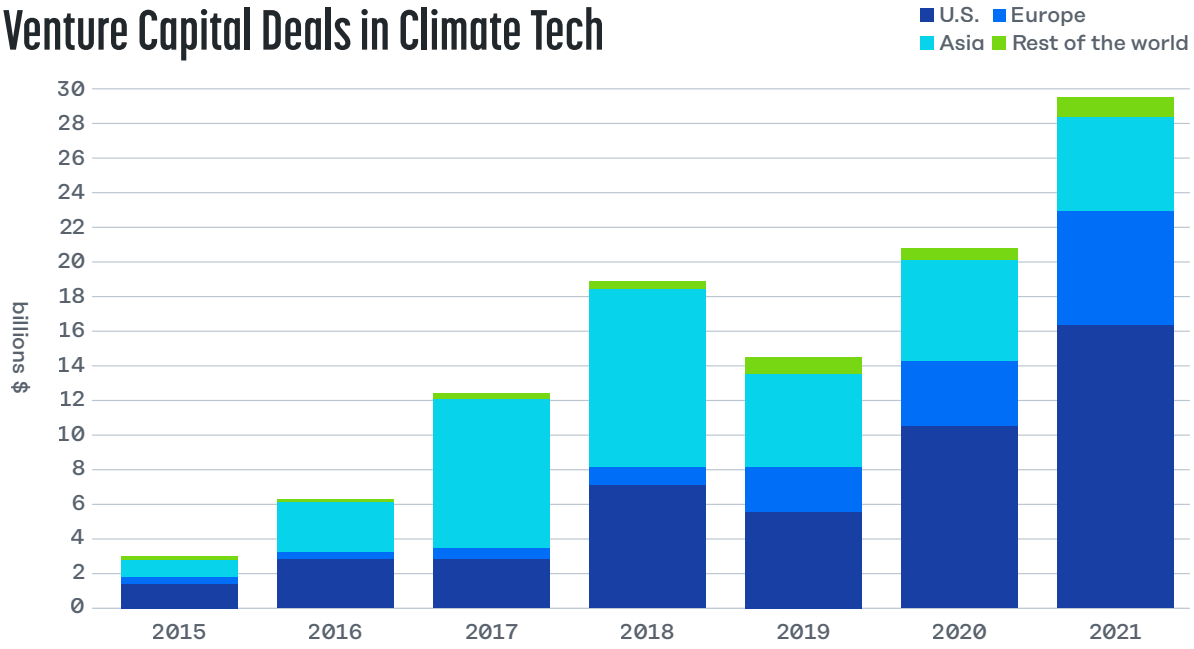
## CROSSING THE VALLEYS OF DEATH

Most entrepreneurs are familiar with the concept of the "Valley of Death," the treacherous space between R&D and market uptake. This is where so many promising companies are starved of the funding they need to turn their proven idea into a product—and then into an affordable product.

Although it is incredibly challenging for any startup to commercialize its product, it is uniquely challenging for clean energy companies. As a software guy learning about energy, my experience building Microsoft isn't analogous to that of an innovator trying to build, say, a massive energy storage facility. We didn't need much infrastructure to write code, and once we'd written it, we could make nearly infinite copies with perfect fidelity for very little money.

The clean energy sector is much more difficult to navigate. Governments fund basic research, and in recent years, investors have begun providing startup capital for clean energy companies. With that support, it may be possible for an innovator to prototype, for instance, a long-duration energy storage battery.

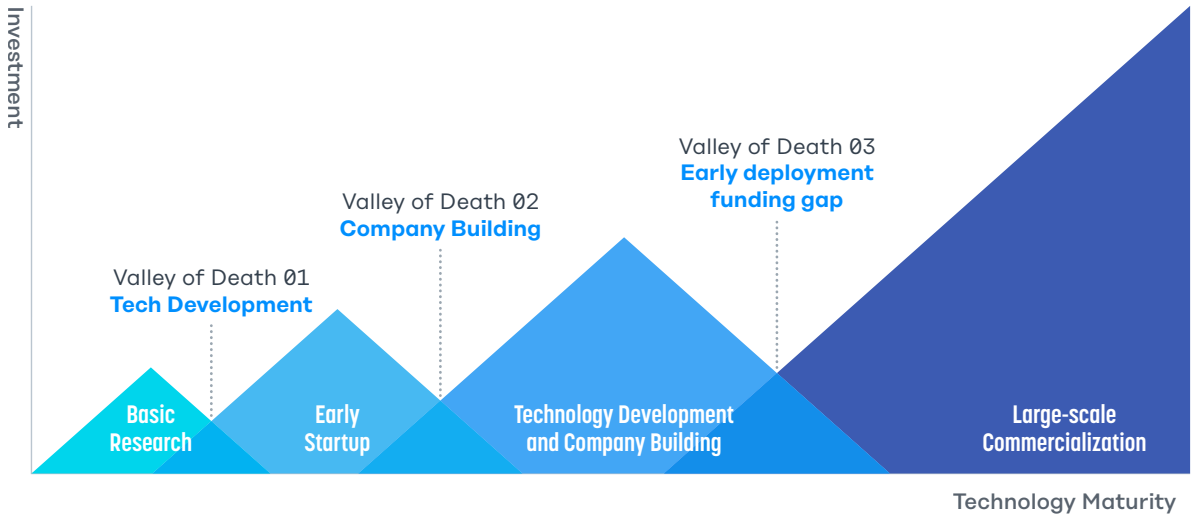
## Venture Capital Deals in Climate Tech




Source: Pitchbook

But what comes next? They have to prove that their battery system is totally safe and reliable. Then they have to prove that it works—and is still totally safe and reliable—at scale. That means constructing an enormous physical plant. Then it means ironing out the engineering, supply chain, and distribution issues that come with building a first-of-its-kind project, optimizing processes by repeating them over and over again, and steadily but gradually cutting costs. Demonstration projects like this are hugely complicated, extremely risky, and extraordinarily expensive—and it's very hard to find capital to finance them.

## The Commercialization Lifecycle

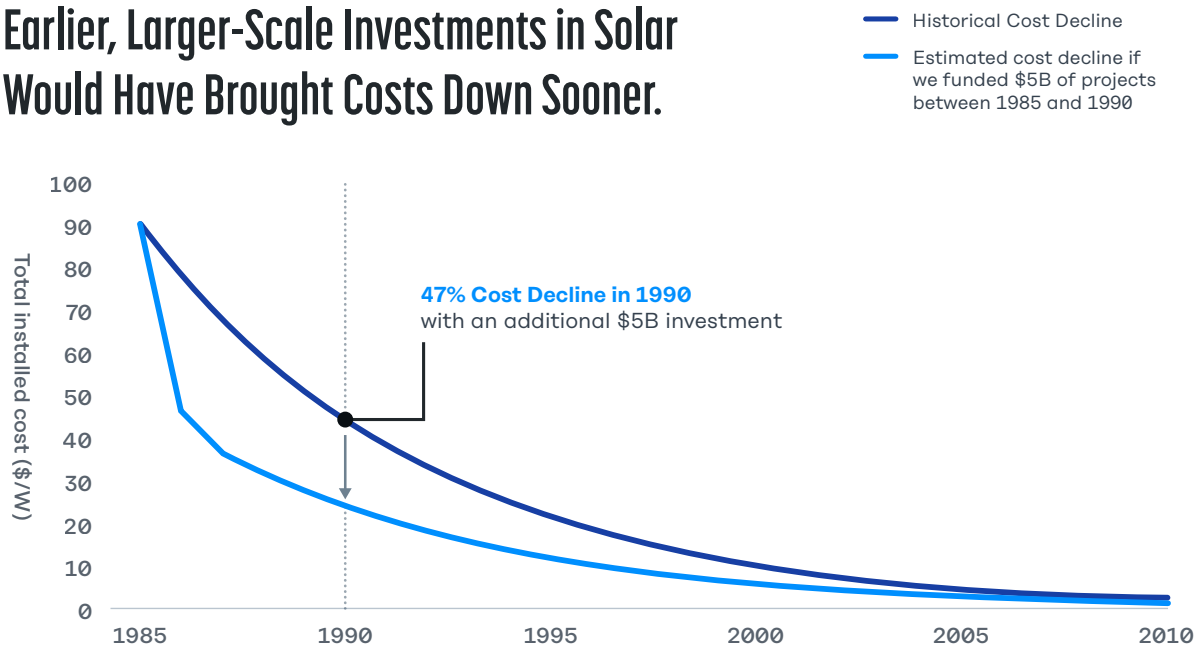


As we have established, clean technologies do not typically provide additional functionality, and they usually come with a high Green Premium. They are, in essence, jet fuel, steel, cement, or electricity that costs a lot more than today's jet fuel, steel, cement, or electricity. Naturally, it's hard to find buyers for these products. Without ready buyers—and with the significant risks described above—banks charge more for loans. The high cost of capital, in turn, increases the Green Premium even more, contributing to a vicious circle. These dynamics help explain why so many clean technologies languish in the Valley of Death.

Consider the long history of innovation in solar power. The technology that makes modern-day solar power possible dates back to 1954, when Bell Labs developed the first silicon photovoltaic cell. After more than 20 years of further development, in 1975, solar panels cost more than $100 per watt. By the mid-1980s, the price was down by a factor of 10, to about $10 per watt. But then it took another 20 years, until the early 2010s, for it to go down by another factor of 10, to less than $1 per watt. At that point, solar truly began to compete with fossil fuels.

Solar got lost in the Valley of Death in the 1980s and 1990s, after government-funded R&D had driven costs down but before the private sector was willing to make significant investments. According to recent models, if $5 billion of investment had gone into solar in 1985, the price could have been almost 50 percent lower than it was in 1990, and solar would have scaled—and started displacing carbon intensive power sources—eight years sooner. That's the kind of progress we need across a dozen or more different technologies in the next decade. The only way to achieve it is a massive effort to fund commercial demonstration projects that scale up markets with unnatural speed.

## Earlier, Larger-Scale Investments in Solar Would Have Brought Costs Down Sooner.




Source: Breakthrough Energy analysis; data from MIT and IRENA

## CAPITALIZING ON CLIMATE CONSCIOUSNESS

So where is that funding going to come from?

Governments can and do fund demonstration projects, and in response to rising public demand for climate action, they have pledged to fund more of them for the foreseeable future. Governments invest in these projects not only to limit climate change but also because they drive significant job growth (because fundamentally demonstration projects are large construction projects) and promote local economic development (because the infrastructure lives for decades and first-mover countries become leaders in new green industries and sell clean technologies to the world).

In the past, however, governments' commitment to climate was fickle. When budgets got tight, clean energy projects were the first to be cut. But recently the opposite has happened. Even during the COVID-19 pandemic and the accompanying economic crisis, many governments are taking the threat of climate change more seriously than ever. We are seeing climate consciousness finally change the way governments act.

The EU's EURO750 billion COVID-19 recovery package is explicitly dedicated to "the green transition." Meanwhile, the package of legislative initiatives being considered by the US Congress has over $100 billion in demonstration funding and tax incentives for these technologies.

Just as important as the direct funding they can provide, governments can also implement policies that incentivize the private sector to invest in demonstration. California was among the first jurisdictions to establish low-carbon fuel standards, which is why much of the sustainable jet fuel in the world is used there. Similarly, the new U.S. federal 45Q tax credit for carbon sequestration will encourage investors to put money into direct air capture projects. Over time, the price for these technologies will drop. The UK's offshore wind auctions has lowered the price of wind energy so much in just a few years that the auctions may no longer be necessary. These examples point the way toward the more ambitious government policymaking that can facilitate innovation toward net zero.

These incentives are so important because governments by themselves are not in a position to manage the process of deploying all the clean technologies we need. Ultimately, commercialization relies on the private sector. At the same time, especially in a space as complicated and heavily regulated as energy, companies need support from governments to deliver products. In short, getting a dozen different technologies across the Valleys of Death in 25 years is going to take a lot of collaboration between governments and businesses.

This brings us back to the new standard of climate impact to which the private sector is now being held—and holding itself. Some companies now see climate action as a long-term economic requirement. As BlackRock CEO Larry Fink has said, "climate risk is investment risk," so if investors are interested in mitigating risk, then they have no choice but to mitigate climate change. That's why in his 2020 letter, Fink predicted that we were "on the edge of a fundamental reshaping of finance." In his 2021 letter, he said the climate-related "reallocation of capital accelerated even faster than I expected."

But whether they're doing it to minimize risk or simply because their boards of directors, customers, employees, and investors are demanding it, companies making net-zero commitments are now casting about for ways to meet them. Among the best things they can do is help clean energy technologies cross the Valley of Death by helping to build demonstration projects, either by providing affordable financing or by agreeing to purchase whatever the project produces.

Unfortunately, the current incentives encourage companies to put their unprecedented clean energy investments in today's technologies, not in tomorrow's. If we don't change those incentives, we risk spending the money unlocked by the surge in net-zero commitments on things that don't actually get us to zero.

## BEYOND THE OFFSET MINDSET

There is only so much most companies can do right now to limit the emissions they produce. Retail companies, for example, don't make steel. So until zero-carbon steel is affordable, every time a retail company builds a new store it will have to do so using steel that emits carbon. Companies have to find ways to indirectly address the emissions they can't eliminate directly.

Currently, companies can get credit for reducing emissions by purchasing offsets, investments in a wide range of projects with climate impact, including forestry and land use or solar and wind power projects. These are worthwhile investments, but offsets as currently conceived do not offer a path to meaningful global reductions, much less zero.

First, the actual climate impact of some offsets is unclear at best. *The New York Times* recently reported, for example, that the wildfires raging in California and Oregon are destroying hundreds of thousands of acres of trees planted to offset climate change. The carbon that was temporarily stored in those trees is now burning, and therefore increasing rather than reducing the greenhouse gases in the atmosphere. Meanwhile, many forms of renewable energy are now profitable, which means some companies buying offsets are getting credit for investments that would have happened anyway.

More importantly, though, even if all offsets worked precisely as advertised, they would do little to incentivize the innovation we need for a global energy transition.

Offsets completely skirt the collective action problem that bedevils the fight against climate change. There will always be governments, companies, and individuals who either can't afford to or don't care to offset their own emissions. Even if every single government, company, and individual could afford to and cared to, there simply aren't enough offsets to zero out global emissions. So until we address the root causes of climate change, the temperature will keep rising. It is one thing to avoid contributing to the problem; it is another to be part of the solution.

What's better than offsetting your own emissions, then, is investing in the technologies that will allow you—and the rest of the world—to eliminate them. For example, when an airline buys sustainable jet fuel instead of offsets, it has impact now, and it also helps bring down the Green Premium on sustainable jet fuel, increasing the likelihood that it and other airlines will switch over completely.

We need to develop a new paradigm for thinking about net zero so that companies get credit not just for doing the thing we happen to measure right now but the thing that will make the biggest difference toward the one number that matters: global net-zero emissions.

## BREAKTHROUGH ENERGY CATALYST

I wasn't exaggerating when I said that getting to zero was going to be the hardest thing humanity has ever done. We need a range of new technologies, we need to build demonstration projects to get the cost of those technologies down, we need to get financing for demonstration projects, we need to change the incentives that direct private climate investment away from these projects—and we need to do all of that in a single generation if we want to have any hope of getting to zero by 2050.

Based on this analysis, Breakthrough Energy, the network of climate initiatives I help to lead, has launched a program called Breakthrough Energy Catalyst. Catalyst is a blended financing initiative inspired by the Gates Foundation's experiences in global health, another sector in which the market does not reliably produce the results the world needs. Over the years, our foundation has helped governments and companies work together to invent and deliver lifesaving vaccines and medicines to people who could not have paid for them on their own.

Catalyst is designed to get governments, companies, innovators, and philanthropists to work together to play their unique role in commercializing clean technology fast. We intend to directly invest up to $3 billion over 5 years to advance vetted projects in four key areas: direct air capture, green hydrogen, long-duration energy storage, and sustainable jet fuel.

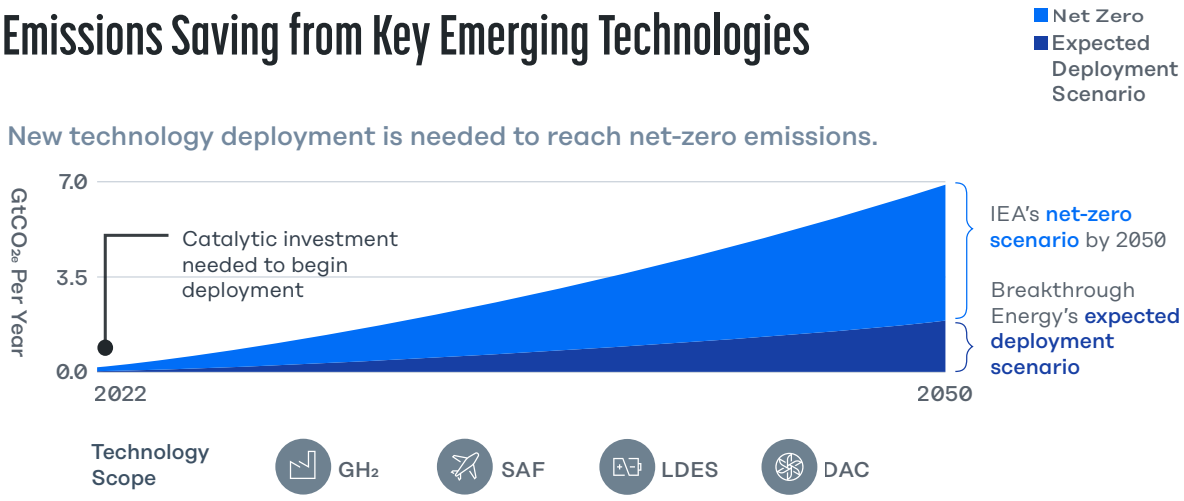
Specifically, Catalyst will do four things. First, it will harness the technical expertise of the Breakthrough Energy network to evaluate which projects are most likely to scale these technologies quickest and cheapest. Second, it will create public-private partnerships that combine government resources with business expertise. Third, it will organize "sub-market" capital—philanthropic grants and equity with a low expectation of return—to be the last-mile financing that will encourage more banks to lend more money at cheaper rates. Fourth, it will structure off-take contracts to demonstrate to lenders that their investments will pay off. One thing it won't do is invest in things that are already financeable through traditional means. While we need trillions in global financing for things like scaled renewable projects, today's financial actors should be investing in those projects without the kind of concessional resources Catalyst will bring.

While we have just gotten started, we are already seeing a lot of enthusiasm for this approach. We have announced partnerships with European Commission and European Investment Bank, the US Department of Energy, and the UK. We have also organized over $1 billion in private capital with our first anchor partners, representing some of the world's largest companies committed to meaningful climate action: American Airlines, ArcelorMittal, Bank of America, the BlackRock Foundation, Boston Consulting Group, General Motors, and Microsoft.

I am humbled by this response, but not surprised since each of those companies recognize how a program like this can lead to both short-term impact and long-term scale. Catalyst projects will start lowering emissions immediately as clean alternatives displace carbon-intensive technologies. They will also accelerate the "learning-by-doing" cycle that drives down costs. In the energy sector, the feedback that has come from decades and decades of production has led to highly optimized industries. With new clean energy technologies, we need to optimize faster, and Catalyst will help get that process started.

According to our team's modelling, the four Catalyst technologies will need to eliminate at least 7 billion tons of emissions annually by 2050 for the world to reach net zero. At the current pace of progress, however, our best estimate is that they will eliminate only 2 billion tons.

## Emissions Saving from Key Emerging Technologies



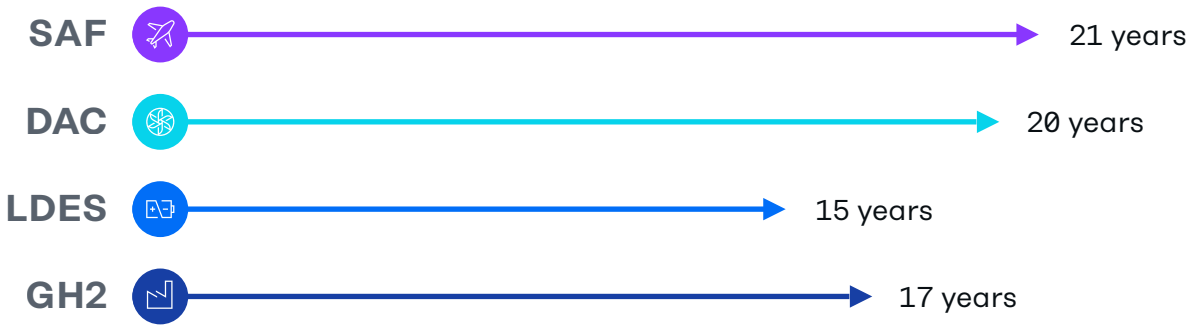

To reach net zero by 2050, we need Catalyst technologies to reduce up to 7 gigatons of emissions annually. Unfortunately, our modeling of expected deployment leaves us short of what's needed.

Source: Breakthrough Energy analysis; data from Rhodium Group and IEA.

Deployment is between 15 and 21 years behind schedule, depending on the technology. That's why Catalyst specifically, and investments in innovation in general, are necessary: avoiding a climate disaster will require closing these enormous gaps. Closing the gaps, in turn, will require bringing down the Green Premium. Direct air capture, for instance, currently costs more than $425 per ton. To get on track to net zero, that cost needs to drop 70 percent by 2030, to $128

per ton, and continue dropping from there to less than $100 per ton by 2050. It will take $100 billion of investment to get the price that low that fast. Across all four technologies, a total additional investment of $784 billion is needed globally to reduce Green Premiums enough to eliminate an additional 5 billion tons and shave 15 to 21 years off the timeline.

## Reducing the Green Premium Will Help Technologies Scale Sooner




Investing $784B to reduce the Green Premium across these technologies will help them get to scale 15–21 years sooner.

Source: Breakthrough Energy analysis; data from Rhodium Group and IEA.

Catalyst will not invest $784 billion directly, but interventions like this will encourage others to invest in scaling these technologies. One way we expect to do that is by accelerating cost declines and making clean technologies more attractive investments much sooner.

Another way we expect to promote investment is by creating a new system—alongside offsets—that recognizes companies for the contributions they make to deploying new clean technologies. Catalyst is working on what we're calling an Emerging Climate Technology Framework (ECTF). ECTF is a sophisticated way of tracking the impact that investments in clean technology have on current emissions, Green Premiums, and future emissions—in other words, on carving the path to net zero. ECTF will allow companies committed to net zero to be recognized for investing in clean technology innovation.

## CONCLUSION

In the introduction, I said that when I think about getting to zero, I imagine an emerging economy 25 years from now. That means that one of the things I imagine is cement. I probably have a greater appreciation for cement than the average person. Cement is amazing. It binds together gravel and sand to make concrete, and concrete is the most widely used material in existence.

Unfortunately, cement is made by heating limestone, which includes the key ingredient, calcium, but also carbon and oxygen. For every ton of cement we manufacture, we also produce a ton of carbon dioxide.

You could argue that the solution to climate change is to use less concrete, to build less. But there are two problems with that, from my perspective. First, it isn't going to happen. China, one of those emerging economies, used as much cement in the first 16 years of the 21st century as the United States used in the entire 20th century.

But second, I believe building less is the wrong approach. Concrete makes durable and safe buildings and roads. It supports lives that are comfortable and convenient. That's why China uses so much of it, and why so many other countries want to as well.

The price of avoiding a climate disaster should not be telling billions of people they cannot build their futures. That would just be trading one disaster for another. It is much better for the world's shared destiny if the price of avoiding a climate disaster is the money and the collaboration it will take to radically accelerate innovation in green cement and other clean energy technology. That is a price the world may finally be willing to pay. It is up to us to turn this willingness into the climate solutions the world needs before it's too late.