Breakthrough Energy

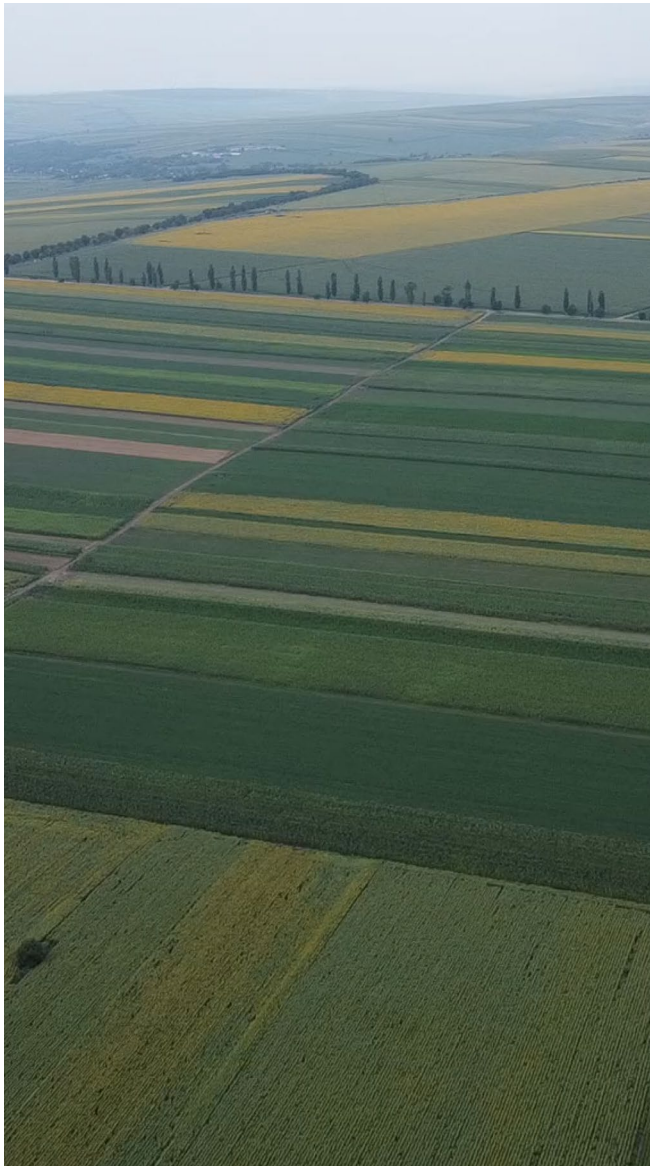
The State of the Transition

Climate Tech Has Arrived  2024

breakthroughenergy.org/transition

Bill's Take

Read a message from our founder, Bill Gates, about the state of the energy transition and why he's optimistic about the road ahead.



Programs

Grand Challenges

Spotlight

Bill's Take

The 2024 "Corporate Climate Pivot"

Climate tech has entered its deployment era, where green premiums are becoming golden opportunities. Now we need corporate pioneers willing to seize them.

In 2024, we've seen climate tech enter its deployment era.

For me, there's a little bit of déjà vu. It reminds me of the early 2000s when I made the transition from Microsoft to my second career in global health philanthropy. At the time, more than ten million children were dying every year. It was heartbreaking—and also infuriating.

Most of the deaths were in South Asia and Sub-Saharan Africa, and were preventable. In many cases, the vaccines or medicine that would've saved children's lives already existed. They were often on the pharmacy shelf in rich countries. But in poorer nations, they were extremely difficult to find.

That changed around the millennium when the world responded, building a global health network that manufactured, paid for, and delivered lifesaving vaccines and medicines to children. Within 20 years, the child mortality rate fell by 50%. That progress came from both scaling existing innovations and inventing new ones. Researchers developed revolutionary methods for preventing HIV and malaria, for example.

All this began in 2000 for the fight against disease, and I believe 2024 is a similar moment for the fight against climate change.

This ecosystem of investors and innovators has achieved a lot already. We've developed technologies that are extremely effective at reducing humanity's greenhouse gas footprint, and we are still developing more.

The next challenge is deployment—scaling these technologies across the economy. This is something large corporations are very good at. But for the past few decades, they've been wary about investing large sums in clean technologies because they've viewed them as mostly emissions reducers that help our environment, not as innovations that can help their businesses.

This ecosystem of investors and innovators has achieved a lot already. We've developed technologies that are extremely effective at reducing humanity's greenhouse gas footprint, and we are still developing more.

Bill Gates, Founder of Breakthrough Energy

This started to change in 2024. At Breakthrough Energy, we noticed a subtle, but important, perspective shift from both the investors and corporations we engage with. Major global investors—including endowments, sovereign wealth funds, and infrastructure investors—are finally getting off the sidelines and engaging in climate tech opportunities in meaningful ways. Meanwhile, corporate leaders increasingly understand that climate tech is not just about shrinking their carbon footprint. It's also about strengthening their businesses and deploying their capital more efficiently.

Take Siemens, for example. They're one of the world's biggest providers of industrial technology and have a massive real estate footprint with 1,300 buildings around the world, both offices and factories.

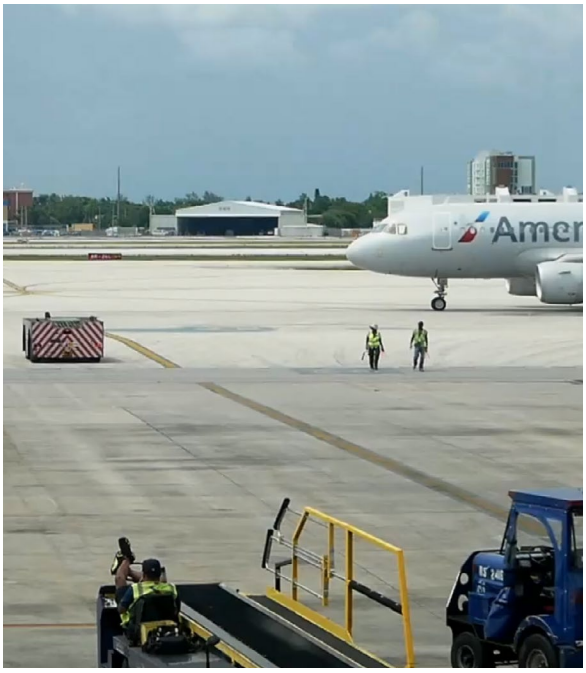
Siemens wants to decarbonize its entire business by 2030, and one way is with windows—specifically, new vacuum-insulated windows invented by a company named LuxWall*.

The math makes the purchase a no-brainer. Siemens' investment will pay itself back within 5-8 years and this cost isn't offset in any way by additional benefits from government tax incentives or subsidies.

Other corporations are investing because they want to get in at the ground floor of new industries that, one day, will be crucial to the survival of their businesses.

* LuxWall is backed by Breakthrough Energy, as are all climate tech companies referenced in this report unless otherwise noted.

A few years ago, most airlines would've dismissed a major investment in SAF as too expensive or risky. But in my experience, the smartest companies take a more serious look at new technologies.



American Airlines is a good example.

They're partnering with Breakthrough across our entire platform. They're working with our team focused on contrails, which account for as much as half of aviation-related emissions. They've also invested in many Breakthrough-backed companies including Graphyte (carbon removal), ZeroAvia (building hydrogen-electric engines for planes) and Infinium (sustainable aviation fuel).

Infinium makes ultra-low carbon eFuels—including a new type of sustainable aviation fuel (SAF)—by combining captured CO2 with clean hydrogen. The resulting fuel can cut aviation's greenhouse gas emissions by about 90%.

The challenge with SAF is that there's still a green premium and production is limited.

A few years ago, most airlines would've dismissed a major investment in SAF as too expensive or risky. But in my experience, the smartest companies take a more serious look at new technologies. They don't just calculate the cost of investing. They also calculate the cost of missing out on a potentially revolutionary new breakthrough for their industry.

In American Airlines' case, securing their own SAF production early means they can position themselves as industry leaders in sustainability and also safeguard their fuel supply chain. Sometimes, people use the term "future-proofing your business" to describe these investments. But they're more than "future-proofing"—they're "future-seizing."

These innovations are ready for prime-time. They're not science projects – they're science products. They work. They're commercially viable.

Bill Gates, Founder of Breakthrough Energy

At Breakthrough, we see American Airlines as a standout corporate partner because they understand that deploying climate tech isn't one dimensional. They see the landscape the way we do at Breakthrough—that it requires engagement at every stage of the climate tech lifecycle, from early pilot projects to scaling these technologies across their business.

The opportunities aren't limited to aviation. The Clean Industrial Revolution spans every corner of the global economy. In manufacturing, there's green steel and net-zero cement. In agriculture, researchers have found ways to replace synthetic nitrogen fertilizer with microbes that convert atmospheric nitrogen into a form plants can use.

These innovations are ready for prime time. They're not science projects—they're science products. They work. They're commercially viable. And with some investment, they can be produced on the scale that large companies need.

More and more companies and investors are gaining a toehold in new global industries.

Going into 2025, the big question is: Who will join them?

Programs

The Climate Tech Pipeline

Innovation is, by its very nature, unpredictable—but it often follows a well-trodden sequence.

At Breakthrough Energy, we talk a lot about the stages of innovation—how each step along a technology's journey from inception to commercialization poses new problems that take new approaches to solve.

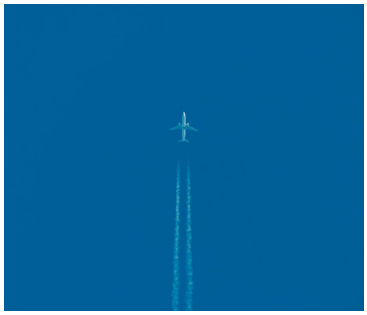
01 Discovery

Who are the most promising researchers and innovators out there? Often they're not where you would think, but working in a garage, or university lab, and the idea of a company is barely a glimmer in their eye.

02 Development

How can these innovators build companies and actually commercialize their ideas?

03 Deployment



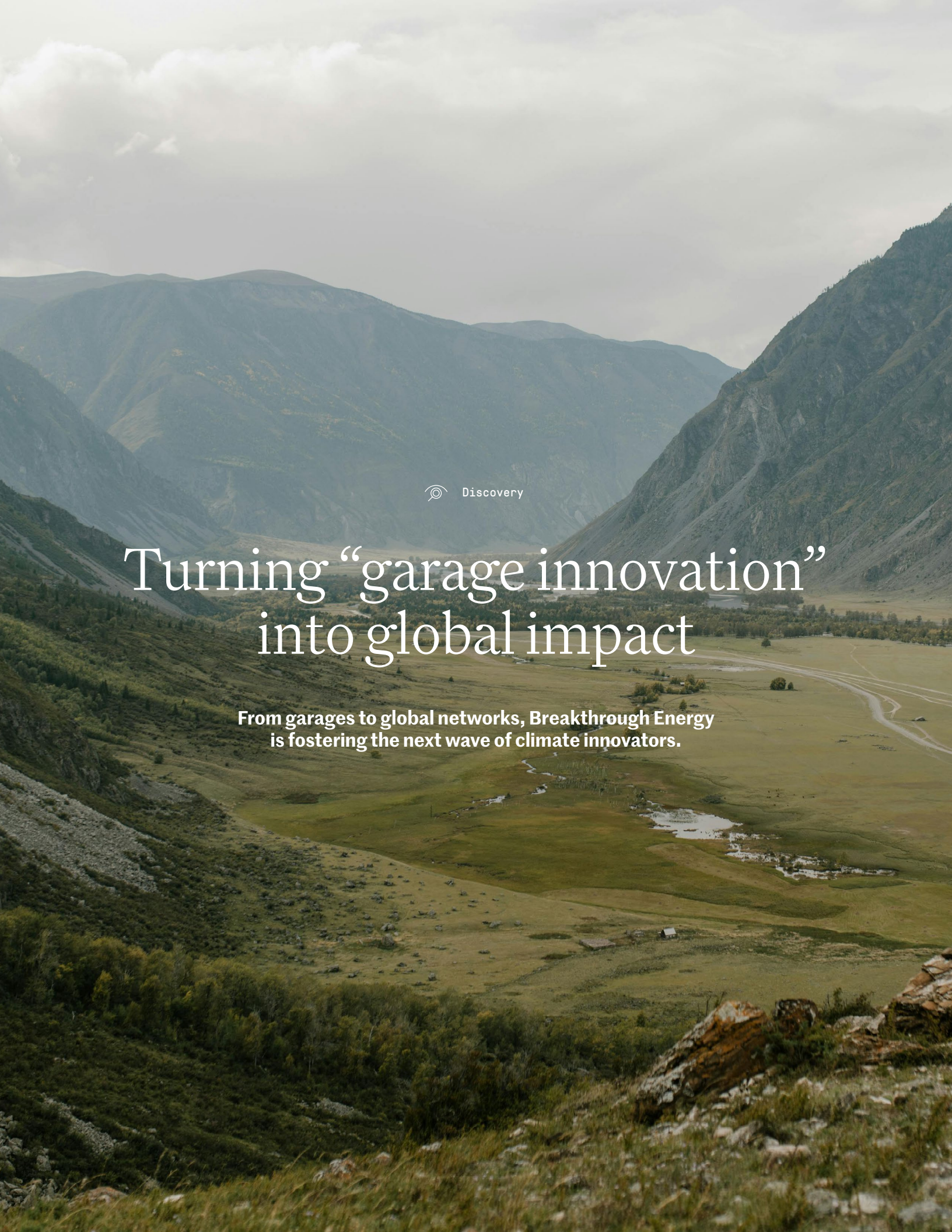
How do we make sure those products find lots of willing buyers and users in the real world?

These steps have been broadly true for every major breakthrough in climate tech. But there's an additional twist in this sector: there's no natural market for zero-carbon products, no matter how exciting the technology is. So we also need policy and advocacy to help these products along at every stage.

Our organization mirrors this process. We're built to pull every lever required for decarbonization—from policy support to capital deployment.

One crucial reason why is Breakthrough's people: We've hired dozens of technical experts, operators, and entrepreneurs.

Breakthrough is widely recognized as the best "technical underwriting team" in the climate space. While no one can truly predict if a given technology will work, our team can generally give a better assessment than most other organizations out there. Just as important, we can spot the gaps in industries—from cement mixing to nuclear power—where more climate innovation is needed.



Discovery

Turning “garage innovation” into global impact

From garages to global networks, Breakthrough Energy is fostering the next wave of climate innovators.

PhD to CEO

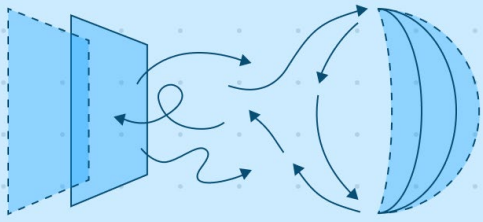
Perhaps no image encapsulates the magic of technological discovery more than that of the scrappy innovator tinkering away in their garage. It's how our founder, Bill Gates, got his start with Microsoft. And it's how many of the companies we work with begin their journeys.

But how does "garage innovation" turn into global impact?

In our 2023 report, we detailed the myriad ways Breakthrough supports early-stage innovators, especially through our flagship BE Fellows program, which offers access to grant funding, a world-class curriculum, and connections to the Breakthrough Energy network of business and technical advisors.

The Fellows program fills a critical gap for companies that aren't yet ready to attract venture investment, spurring new innovation that might otherwise never get off the ground. Breakthrough's experts serve as thought partners for the Fellows throughout their journey in the program, helping them avoid, prepare for, or weather the inevitable speedbumps involved in scaling their technologies and bringing them to market.

Beyond funding and expertise, the program also provides the Fellows with a vibrant community of early-stage innovators. Many climate innovators are spread out across the country and around the world, with no



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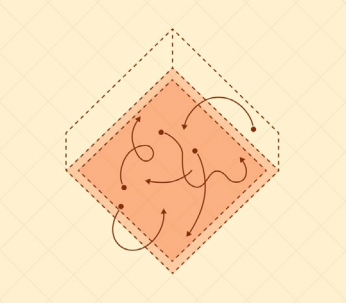
Over the last year, we've continued to make remarkable progress, surpassing 100 fellows across 16 countries since launching our initial cohort in 2021. These teams have already raised nearly $250 million in follow-on funding to further support their road to market. In addition to the technical progress and capital these Fellows teams have been able to attract, we are guiding them through our curriculum and programming to help build out their technologies and become stronger leaders.

But we're ready to do more, to fill more gaps across the early-stage ecosystem.

That's why at this summer's Breakthrough Energy Summit in London, we reviewed a broader set of Breakthrough Energy Discovery efforts that expand our ability to support and accelerate pre-venture climate innovation.

This work is divided across three areas.

Ashley Grosh announces Breakthrough Energy Discovery at the BE Summit in 2024



Supporting Bold Thinkers

First, we will continue to find and support bold technical thinkers through our flagship Breakthrough Energy Fellows program. This program supports Innovators—who typically have a company and early-stage technology to commercialize, Explorers—who are working at an even earlier stage, typically still in a national lab or university setting, and Business Fellows—seasoned industry experts who serve as navigators, providing commercialization and business advisory to all of our projects.

BE Fellows look book ↗

Innovators	who typically have a company and early-stage technology to commercialize
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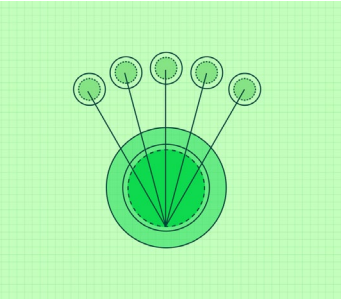
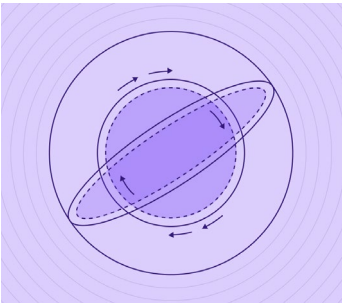


02

Seeding New Ideas

Second, we've launched Discovery Workshops, a proactive effort to go further upstream into a specific technology area and identify gaps that need further exploration. We want to take ideas, theory, and science and steer them towards new, breakthrough applications, long before they enter the lab or even a garage. These workshops convene experts from around the world to help us dig deeper into some of the most exciting technology horizons—from hydrogen carriers to superconductivity to new battery chemistry—with the ultimate goal of funding applied research in these high-impact areas. The workshops have already generated promising ideas that have earned Explorer grants and could potentially become Fellows projects.



03

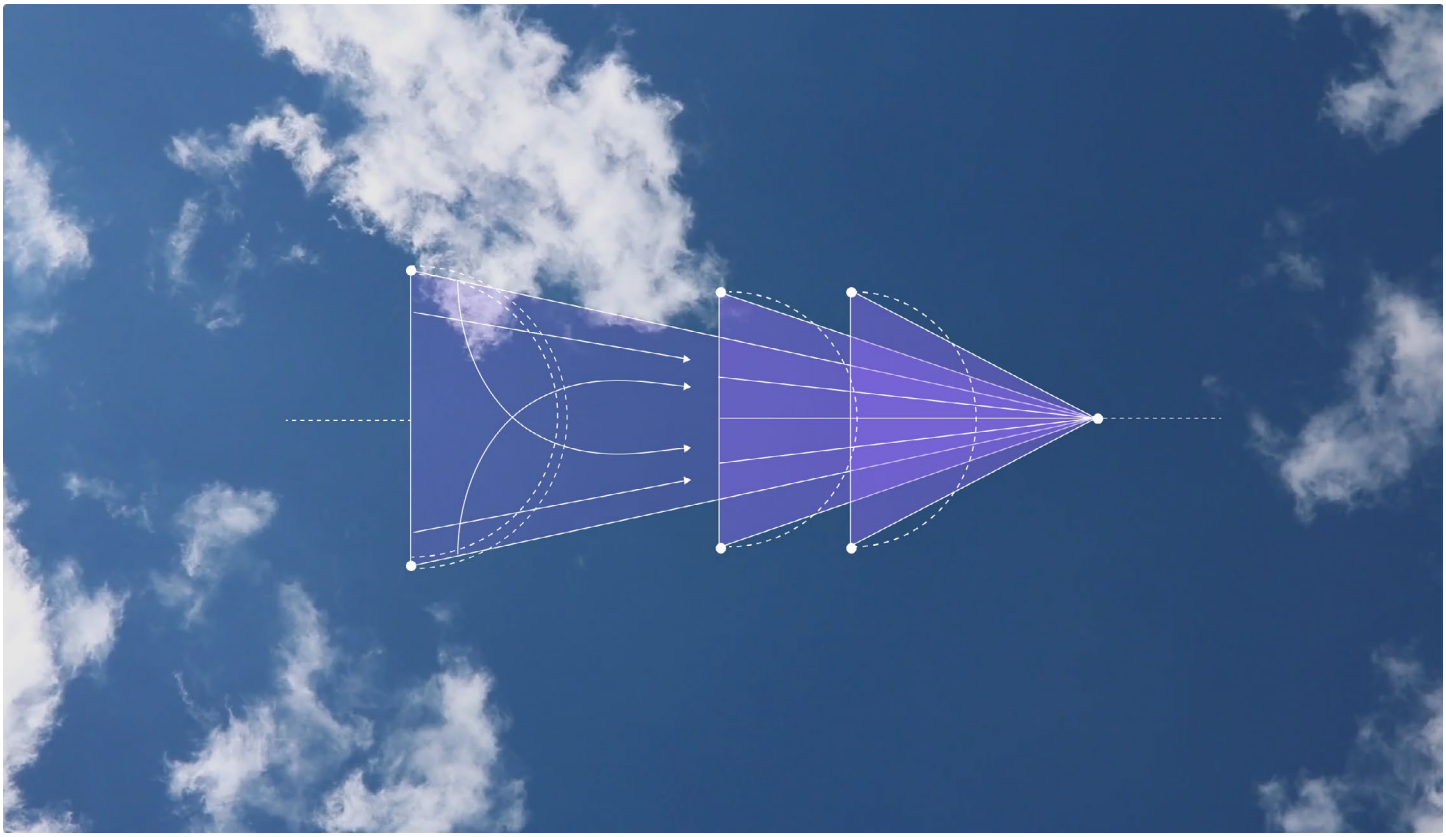
Fostering Global Ecosystems

Third, we're helping to stitch together global innovation ecosystems, connecting climate platforms across academia and collaborating on where our Discovery model can be replicated and expanded. Working hand-in-hand with other accelerators, incubators, national labs, and research institutions is critical to success at these early stages of climate technology development.

For example, earlier this year we announced our first Fellows hub outside of the United States. Working closely with regional partners Temasek and Enterprise Singapore, BE Fellows—Southeast Asia hopes to foster climate tech entrepreneurship throughout the Southeast Asian region.

Why Southeast Asia?

The region is filled with diverse talent, strong technical universities, and access to many key industrial partners that are critical to helping new technologies get adopted into the marketplace. But like many promising markets, Southeast Asia also faces significant funding gaps, including for innovation, that need to be addressed in order to meet ambitious net-zero climate goals. Supporting regions like Southeast Asia is vitally important—not just because it will help bring global emissions down, but because much of the population is on the front lines of the extreme impacts of climate change.



Infinite Innovation

Why Discovery

Our expanded efforts, and the launch of this platform, didn't come together overnight. It's the result of hundreds of hours of conversations with innovators, climate experts, and business leaders.

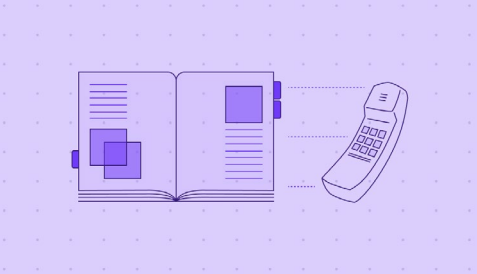
With Breakthrough Energy Discovery, we believe that innovation is infinite: it is the engine that drives forward progress. We also believe that innovation is rarely linear: it is filled with false starts, long detours, and happy accidents. However, what we can control, and replicate, are the time, space, and resources needed to foster that innovation and give it the best possible chance to succeed. That's exactly what our platform does.

Development

Patient Capital ≠ Lazy Capital

Climate tech has become one of VC's most attractive sectors. Now, the money needs to be matched by elbow grease.

A decade ago, you could've searched the Silicon Valley phone book (those still existed) and turned up only a handful of venture capitalists willing to invest in climate tech.



Some didn't know what "climate tech" was. Those who did know thought it was "too risky." Investments in the early 2000s, when the area was hotter, hadn't panned out.

Today, things have changed. Investors know what climate tech is—and many want in.

Breakthrough Energy Ventures is the venture capital arm of Breakthrough Energy. Over the past nine years, we've invested $3.5+ billion into over 110 climate tech companies. We're constantly learning more about these technologies and markets. So, we're always adjusting our investment strategy.

Since last year's report, we've been focused on this question: How can our portfolio companies collaborate more—both with larger companies who may benefit from their technology and with investors who provide different skillsets?

This, we're finding, can be a game-changer for our portfolio companies (and all climate technologies). It helps them find their place in the larger story about climate change being told across all parts of the economy—from governments, to investors, to large corporations.

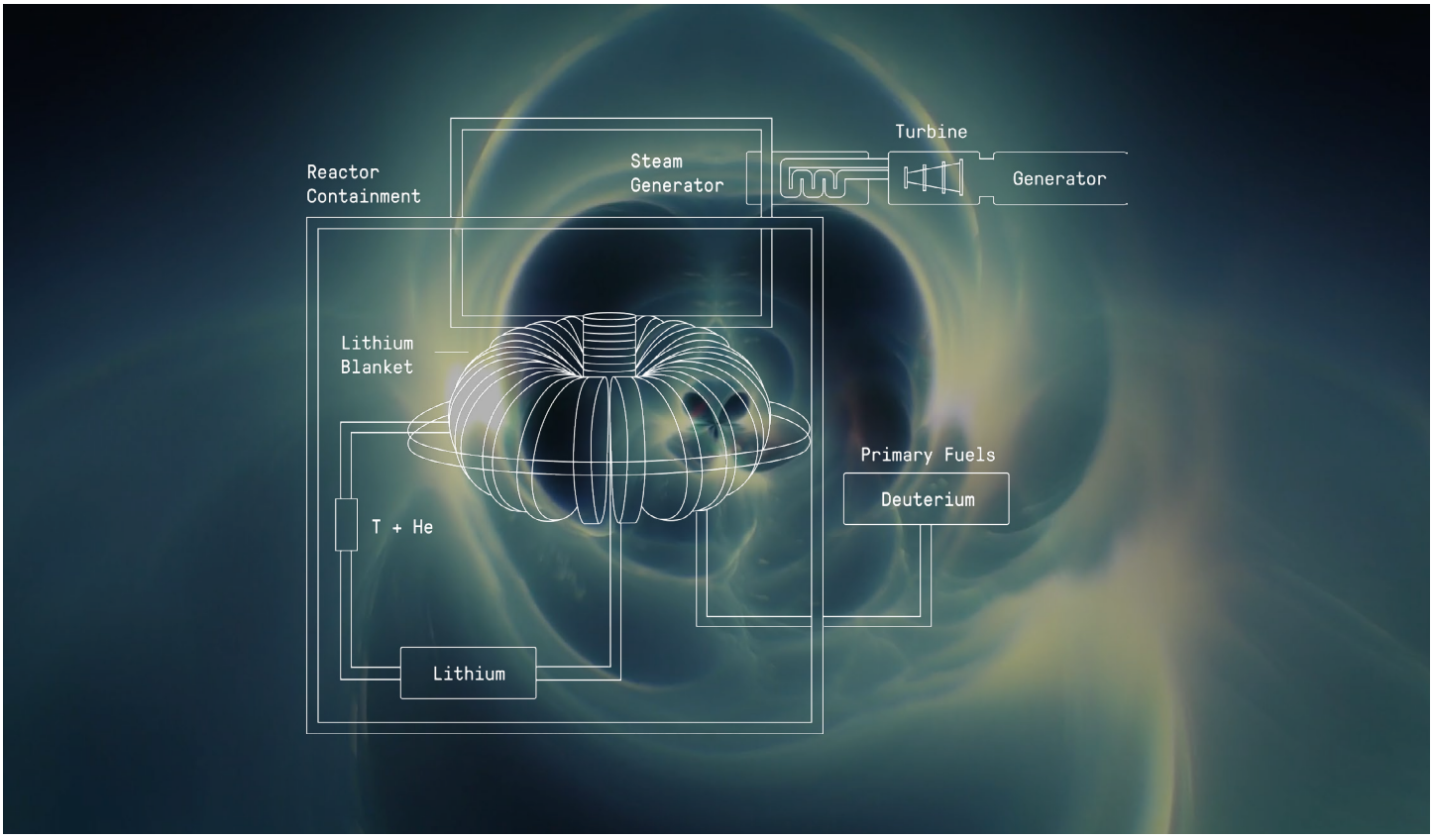
BEV invested more than $3.5B In over 110 companies

Collaboration

Capital is always critical, but so many fledgling companies could benefit even more from a quality partnership with an engaged investor. Someone who doesn't just write a check, but checks in. Someone who offers support and expertise during the inevitable lows every early-stage company endures. Someone who doesn't simply attend monthly calls and quarterly board meetings, but jumps in and helps problem solve.

These companies need a true partner. And a true partner sometimes has battle scars. A true partner can cite instances of when they joined their companies in the foxhole and helped them find a way out.

Of course, it's easy to say all this in theory. But our Ventures team is showing how it's done in practice.



Take fusion technology, for example.

We often call fusion the holy grail of climate tech because of its potential to provide energy abundance the world over. But it's also deeply complex— a fact that can repel many potential investors who don't want to cut a check for something they don't understand.

Instead of leaving this educational heavy lifting to our portfolio companies, the Ventures team drafted a 100+ page technical diligence report that could be shared with investors.

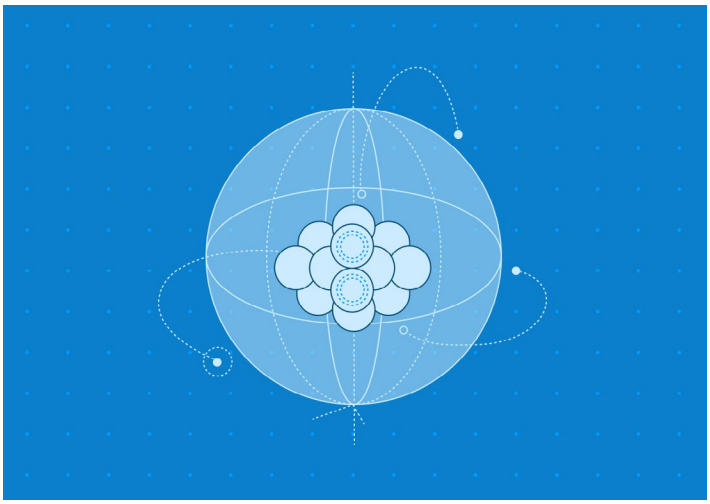
This report tackled two questions in painstaking detail:

01 If this technology works, will it matter? (In fusion's case, the answer is obvious: Yes!)

02 Even if this technology works, is it economically feasible? (Perhaps.)

The 100-page report dove deep into the economics of building a fusion reactor, understanding that the final cost would be somewhere between the current cost and the cost of the raw materials. It focused on a company aiming to upend those economics with a new magnet.

With fusion, it's magnets—very *advanced*, superconducting magnets—that contain the reaction and keep it going. Currently, these magnets are enormous. In some cases, they're 54 feet tall, 12 feet wide, and weigh 1,000 tons.



Breakthrough Fusion Companies

Commonwealth Fusion Systems
Fusion

Marathon Fusion
Fusion

Type One Energy
Fusion

Xcimer
Fusion

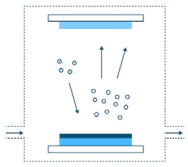
Zap Energy
Fusion

Check out the Full Look Book↗

High temperature superconducting (HTS) magnet developed by Commonwealth Fusion Systems

The magnet's size is what provides the tremendous magnetic force required for fusion (roughly 280,000 times Earth's magnetic field).

The size is also what makes it costly.



The precision could potentially let engineers build fusion reactors at 1/50th the size.

If engineers could pack the same amount of magnetic force into a much smaller magnet, the economic viability of the technology would be more likely. Which is why the report looked at new methods for building magnets using thin-film deposition technology, where the superconducting material is applied atom by atom. The precision could potentially let engineers build fusion reactors at 1/50th the size.

Is the future of global energy through super-small, super-powerful magnets? It's a thesis worth investigating—for at least 100 pages. Because with climate tech, the answers to fundamental questions are rarely black and white. Green contains many shades of gray. And these reports help investors see that grayness in all its complexity.

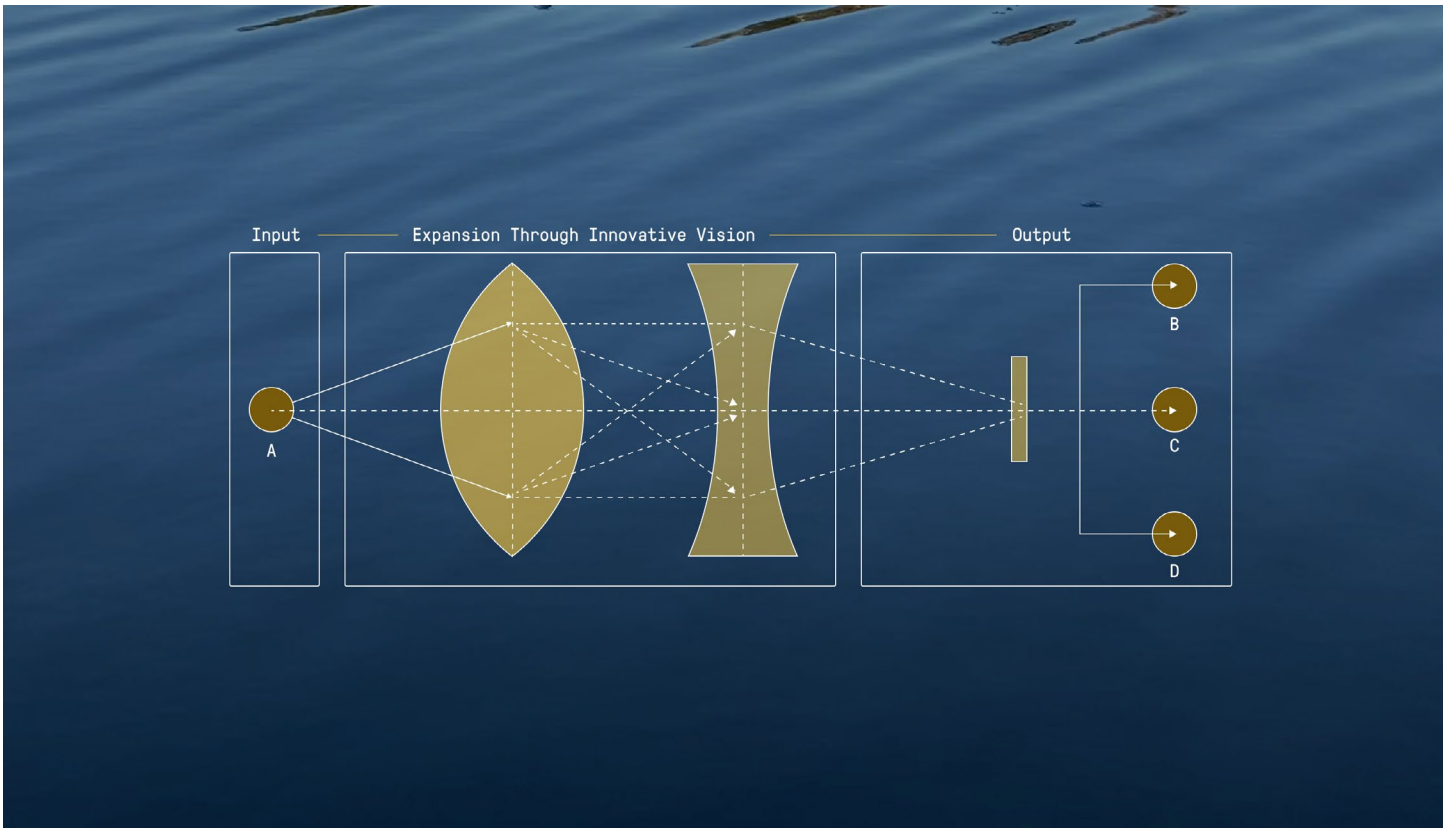
We heard from nearly a dozen major investors that our work was transformative in their decision to invest in the fusion space.

Priming the Pump

This proactive collaboration is especially important in the early stages of a company's life. Right now, a lot of investors rely on a rigid set of criteria. If they have 10 boxes and the company they're evaluating only checks five, they move on. They're not willing to risk a $15 million investment on a technology that doesn't meet their checklist.

But by waiting, venture firms are only hurting their own bottom lines. Either they're never going to see anything worthwhile come out the pipeline, or they're going to make an investment in a firm that's not ready to scale.

That's where we, as investors, need to change our way of thinking.



At Breakthrough, we help innovators at all stages of the company-building process. Our Discovery program brings the best ideas out of the lab. Our Deployment program helps companies scale and go to market. But it's Ventures coming in at the development stage that helps nascent companies turn their technology into a real product. This critical Development stage is where we can expand our reach.

Instead of waiting for perfect companies to emerge fully formed and check all of our boxes, investors should be more proactive about jumping in early, with a smaller dollar amount, to help early-stage companies work out the kinks and get to a place where they can attract a bigger investment. In other words, they need to prime the pump.

This approach won't just result in better companies and stronger partnerships. It could also help increase diversity in the entrepreneurship space by providing support for innovators who are typically overlooked by venture investors.

A few of our external partners and co-investors are already engaged in this critical work alongside Breakthrough. Venture capitalists like the legendary John Doerr and Vinod Khosla have been doing this work for years, partnering closely with early-stage companies to make sure they're ready for commercialization. These VCs and their firms have a deep understanding of the unique challenges of climate technology.

Then, there are newer firms that were built from scratch to support climate tech, such as Prelude Ventures. Breakthrough works closely with their partners, including Gabriel Kra and Nat and Laura Simmons.

Another example of these climate-first VCs is Katie Rae and her team at Engine Ventures, an MIT spin-off investing in "Tough Tech" founders in climate, health and advanced systems. They provide capital, hands-on expertise, and access to an extensive network spanning academia, industry, and government. These networks are especially vital for climate tech, which, unlike the traditional tech sector, doesn't have a universal hub like Silicon Valley.

That's where we, as investors, need to change our way of thinking.

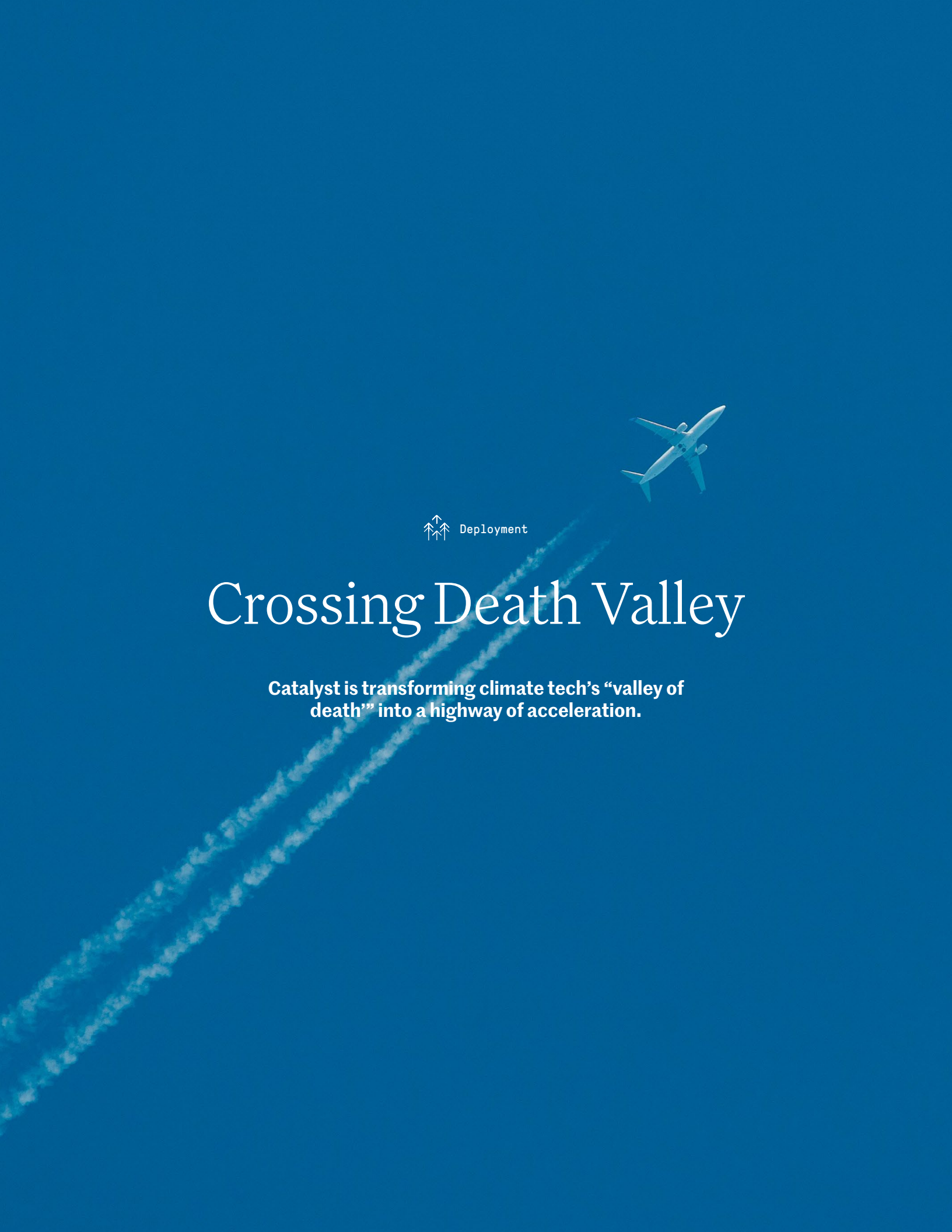
It's also important to help promising young ventures reach escape velocity. In June, we closed our Select Fund I, which will invest in roughly 15 to 20 climate startups that have overcome their early hurdles. Their technology was proven, and they found a market for it. In some cases, they're already making money. And they can reach the next level of deployment with extra capital and assistance.

Uncertainty

Ultimately, one of the main hurdles to this kind of investing and partnership is not risk, but uncertainty. Investors are creatures of habit. They're not eager to veer from their tried-and-true formula. But by grasping the opportunity to get in early and partner in the right way, they'll realize there's a lot less uncertainty than they think. Because by getting in before anyone else and using their expertise to guide a company forward, they're helping build something they'll understand better than the rest of the market.

And that's a huge investment opportunity.

So whether you're a government setting the guidelines for a grant, a large company defining its requirements for a deal, a lender, an investor, or an incubator, don't be constrained by pre-set criteria. Don't be handcuffed by uncertainty. Go early, use your expertise, and be a true partner. Breakthrough will be right there alongside you.



Deployment

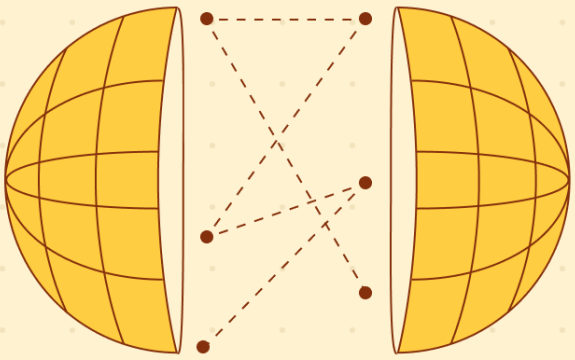
Crossing Death Valley

Catalyst is transforming climate tech's "valley of death'" into a highway of acceleration.

Scaling Challenge

Even after climate technologies are discovered and developed, it's not a given they'll get out into the world and reduce emissions in a major way.

As we have seen in the past year, emerging climate technologies continue to face significant challenges, many of which are becoming even more pronounced.



First Of A Kind

Catalyst

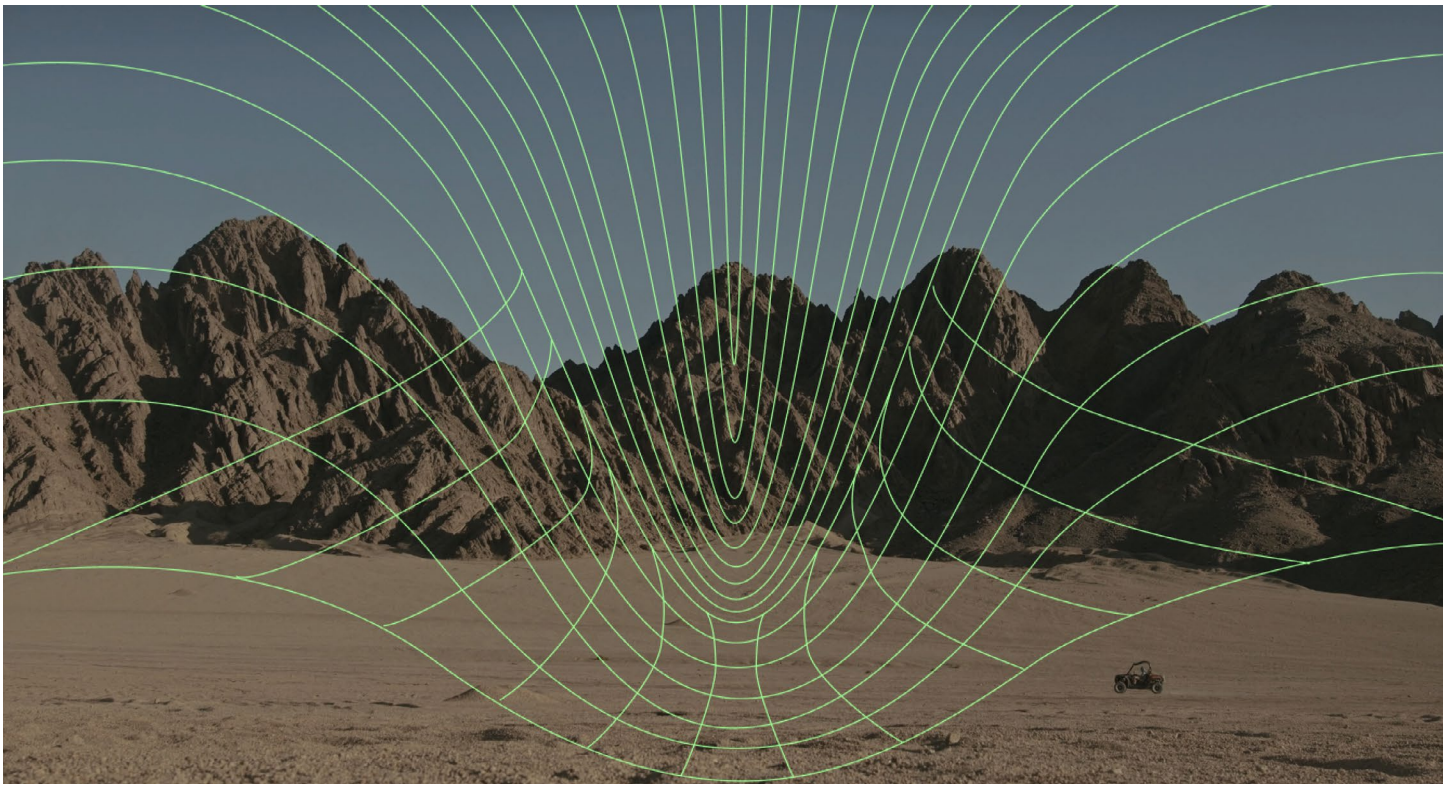
One of those challenges is building first-of-a-kind (FOAK) projects. That's where our core Deployment program, Catalyst, comes in. It's tackling a few key problems that projects and their companies face.

01 First, economic viability: Inflation, high interest rates, and regulatory challenges often turn promising projects into marginal potential from a risk/return perspective.

02 Second, challenges in engineering, procurement, and construction (EPC): First-of-a-kind projects frequently blow their budgets and face execution risks due to their untested nature.

03 Third, slow project deployment: Early-stage companies often lack the expertise to develop projects quickly and efficiently, leading to delays and costly mistakes.

04 Fourth and finally, funding beyond capex: Projects need more than just capex funding, requiring flexible and creative solutions.



These hurdles, among others, ultimately cause many companies to never make it across the much-dreaded "valley of death" between development and deployment.

Catalyst's goal is to turn the "valley of death" into a much more survivable landscape for emerging climate technologies. Through a combination of capital and project-development expertise, we help companies fill the gaps inherent in the late-stage march toward construction and commercialization.

We've identified five areas ripe for our unique approach: clean hydrogen, long duration energy storage (LDES), sustainable aviation fuel (SAF), direct air capture, and decarbonization of industry.

Overall, we've raised more than $1 billion of direct capital to deploy, and we've partnered with the European Commission (EC) and European Investment Bank (EIB) to mobilize up to €820 million through 2027 to support projects across Europe.

Breakthrough Energy Catalyst and the European Investment Bank Announce €75 Million of Funding for Rondo Energy

↗

The past year, in particular, has been a big one for us:

Grant commitments for improved energy storage and power grid services

Catalyst funded the first tranche of its grant commitment to Energy Dome's Ottana Project. Construction on this 20MW/200MWh CO2 battery has begun, and once fully operational, it will help provide energy storage and grid services.

Energy Dome
Ottana Project

Energy Dome's first full-scale CO2 Battery (rendering) in Ottana, Sardinia, Italy

€75 million partnership for decarbonization projects in Europe

At the Breakthrough Energy Summit in London, Catalyst unveiled a €75 million partnership with Rondo Energy that will support three groundbreaking industrial decarbonization projects in Europe. These projects, which also fall under the umbrella of our partnership with the EC and EIB, will provide "drop-in" decarbonization technologies to chemical, clean fuel, and food and beverage producers at a time when many in those industries are eager to end their dependence on natural gas.

Rondo Energy
EU Projects

Rondo Energy uses refractory bricks to store heat

$75 million equity commitment to sustainable aviation fuel

Catalyst announced a $75 million equity commitment to Infinium's Project Roadrunner, which will convert waste carbon dioxide and renewable power into sustainable aviation fuel and other low-carbon fuels—one of Catalyst's five areas of priority investment. Once operational, this first-of-a-kind facility is expected to be the largest power-to-liquids eFuels project in North America. Catalyst's early-stage backing is already helping Infinium attract institutional capital. In September, Brookfield Asset Management announced up to a $1.1 billion commitment to support Infinium's eFuels platform.

Infinium
Project Roadrunner

Project Roadrunner will be the largest commercial-scale eFuels project in the world when production begins

Beyond these major developments, we've also given a lot of thought to what it takes to scale emerging climate technologies. We've had extended conversations with experts, investors, and innovators in the venture ecosystem about the challenges and opportunities companies face when trying to secure capital, and how to turn the perilous "valley of death" into a highway of acceleration.

The problem is not a lack of capital in the system. The capital exists. What's more, venture capital and private equity are hardly the only players. In fact, there is much cheaper and more significant capital to be found through infrastructure equity and project finance debt.

What's the catch? Well, these more traditional sources of funding are a lot harder to get. They have a highly rigid set of criteria for their capital investments, including seeing millions of operating hours, which new climate technologies simply will not have.

So, how do we help companies meet these criteria and unlock this abundance of cheap capital? Well, after analyzing over 200+ projects, we have developed a deep understanding of the "do's and don'ts." And the main "do" is companies actively committing to taking their technology from pilot to commercial scale. Without this commitment, reaching full commercialization becomes a nearly impossible feat.

We always say we're as much a partner to companies as we are a funder of projects. In that spirit, we've packaged this understanding and other key lessons into what we're calling the "12 Keys to Scaling-Up," a helpful guide for companies to navigate the de-risking journey and improve their chances of securing cheaper sources of funding. We're excited to share this with the climate venture ecosystem through live webinars and workshops, as well as a brief summary on the Breakthrough Energy website.

Catalyst has had an incredible 12 months. And we're looking forward to building on our progress over the next 12.

Unlocking Capital for Climate Tech Projects: The 12 Keys to Scaling-up ↗

The problem is not a lack of capital in the system. The capital exists.

Go-to-Market Partnerships

First-of-a-kind projects are just one piece of the deployment puzzle. Lots of climate solutions don't require capital-intensive FOAKs. They just need customers, in the form of forward-leaning businesses, to dive in and help them scale up.

Across our teams, BE works closely with numerous corporations and business leaders around the world to understand the demand for these products and what the BE network can do to help fulfill it. We connect serious business players with innovators who can supply solutions at scale today, while also providing companies with a trusted source of innovative technology that's well-vetted.

Corporate players are not a monolith.

Some seek out these innovations to fulfill their net-zero commitments and make a climate impact. Others are more interested in securing the energy resources they need to power their businesses. All are important to our strategy.

For example, as Bill mentioned in this report's foreword, Siemens is working to decarbonize their buildings with vacuum-insulated windows invented by Breakthrough's portfolio company, LuxWall.

Microsoft is also taking action on this front. CarbonCure's low-carbon concrete, which we discuss in the Manufacturing section, was recently used to build two Microsoft data centers.

This is just a snapshot of the range of companies, across various industries, that are tapping into the BE network to find and deploy these go-to-market solutions.

Solving problems in a lab or scaling technologies that are only affordable for wealthy, developed countries won't be enough.

If we want to bring down emissions, we have to be able to deploy new climate technologies around the world in an efficient, cost-effective fashion.

By continuing to help fill these gaps in deployment, we can ensure the best climate technologies get to market and begin making their impact on our energy future.

Buildings

LuxWall

LuxWall manufactures tempered vacuum insulating glass (VIG). VIG is 1/3 the thickness of double pane glass and is 500% more energy efficient.

Learn More

Manufacturing

CarbonCure

Architects, structural engineers, owners, and developers are seeking proven ways to reduce the embodied carbon of their building projects.

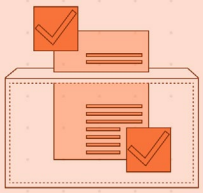
Learn More

Policy

Election Night for Climate Tech

In history's biggest election year, climate policy is evolving from promises to projects.

As of this report's publication, the world is most of the way through history's biggest election year. Roughly 76 countries, including the U.S., representing 4 billion people, will cast ballots through the end of 2024.



There does appear to be a subtle—but important—shift in the way governments are approaching the clean energy transition.

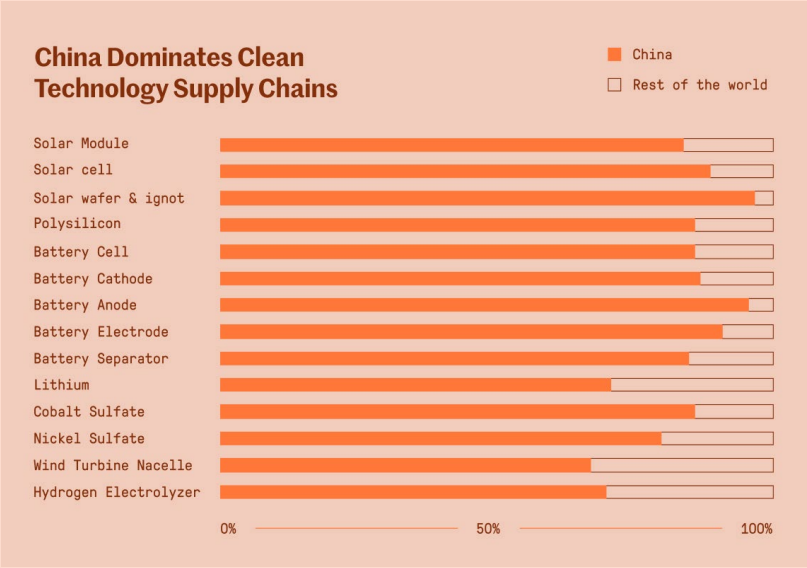
We're seeing a new focus on implementing existing climate policies – not just making new ones.

That's true for most of the countries that have held elections this year, regardless of the parties or leaders who won.

In many cases, countries are responding to China's ability to manufacture climate tech.

From solar cells to hydrogen electrolyzers, China far outpaces the rest of the world. This flood of Chinese tech is driving down prices, but those lower prices on Chinese goods are creating challenges for other countries as they try to compete with their own climate tech.

What follows are key insights about the regions where Breakthrough Energy focuses the bulk of our operations: the United States, the United Kingdom, and the European Union.



Source: BloombergNEF

United States Capitol Building

The U.S. Update:

Green, White, and Blue

Within the Department of Energy's (DOE) Washington headquarters sits the Industrial Demonstrations Program, or the IDP. Despite its inauspicious name, this little-known initiative is actually the beating heart of America's Clean Industrial Revolution.

The IDP was created, in part, by the Inflation Reduction Act. With a $6 billion war chest to invest, it represents the largest federal pool of funding ever devoted to reducing the carbon footprint of the industrial sector, which accounts for nearly a quarter of U.S. greenhouse gas emissions.

Over the past year, climate tech innovators submitted 400 proposals for a share of the $6 billion. Among the 33 projects the IDP selected, 12 were Breakthrough Energy–backed initiatives, including:

01 Brimstone's revolutionary cement production facility

02 Antora Energy's partnership with Summit Materials to decarbonize their clay-based cement alternatives

03 Rondo Energy's collaboration with Diageo to replace natural gas with heat batteries in beverage production; and another Rondo project with Eastman using heat batteries at their molecular recycling facility.

This has been a core focus of Breakthrough Energy's U.S. Policy team: Turning the thousands of pages of new clean energy legislation into clean energy projects.

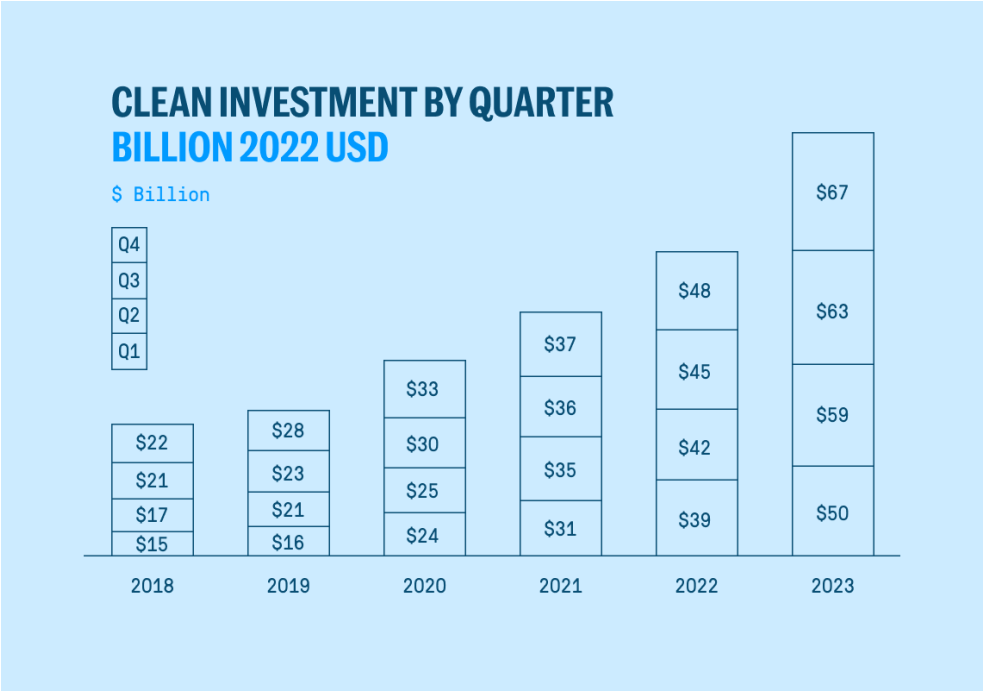
Breakthrough Companies

Brimstone
Decarbonizing cement

Antora Energy
Thermal Energy Storage

Rondo Energy
Batteries, CO2 to X

Check out the Full Look Book↗



IRA/BIL spurred an increase of public and private capital into clean energy markets, hitting a record $239 billion in 2023, a 40% increase compared to 2022.

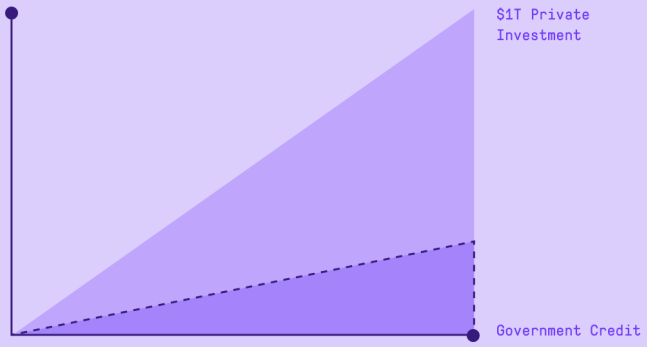
Here are some of the 2024 highlights

01

$1 trillion unlocked

from government credit

Through the Inflation Reduction Act, the U.S. federal government now offers over two dozen tax credits for investors who put money into building clean energy projects. But before the money can start flowing, the Internal Revenue Service and Department of the Treasury need to issue final guidance on how those tax credits can be used. The good news? Over the past few years, the federal government has been releasing a steady flow of guidance, which Breakthrough Energy believes will unlock more than $1 trillion in private sector investment.



02

$40B boost

for clean hydrogen

The Department of Energy announced $8 billion in funding through the Bipartisan Infrastructure Law for the creation of seven regional clean hydrogen hubs and a $1 billion demand support mechanism. This program, called H2Hubs, will reduce carbon dioxide emissions equivalent to 5 million gasoline-powered cars—every year. Just as important, the projection is that the government's $8 billion investment will spur an additional $40 billion in private investment.

03

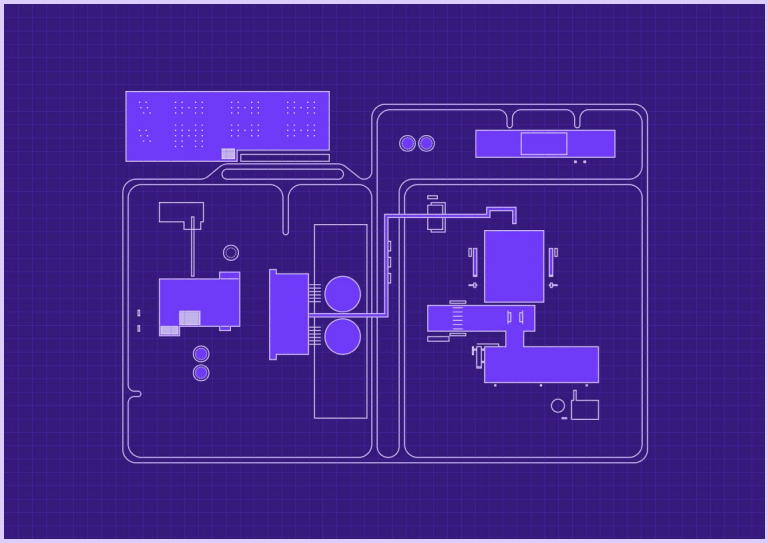
Gen 4 reactors

More nuclear power (finally!)

America's First Next-Gen Nuclear Facility

↗

Congress passed the ADVANCE Act, which will modernize the Nuclear Regulatory Commission (NRC) and allow the U.S. to finally unlock the limitless potential of nuclear power—namely, by streamlining the process for licensing new Generation 4 nuclear reactors. One example is TerraPower's first-of-its-kind nuclear plant. It's now under construction in Wyoming.



04

Interstate Power

A big FERC-ing deal

In May, the Federal Energy Regulatory Commission issued a landmark ruling around transmission planning and cost allocation—arguably the most significant regulatory milestone concerning intrastate power lines in three decades. You can read more about it here:

Grand Challenges
Transmission

As energy use grows, our capacity to move that energy remains stubbornly stagnant with woefully outdated power grids that weren't built with renewable energy in mind.

United States Supreme Court Building

A Watchout

One thing to watch out for: a Chevron doctrine–less America.

The Supreme Court's recent elimination of four decades of legal precedent, known as "the Chevron Doctrine," could stunt the progress of the clean energy transition. Following the Court's ruling, regulatory guidance won't be decided by experts in agencies like the EPA. Instead, it will fall to Congress. Additionally, federal agencies could face a flood of legal challenges when they try to take any action regarding climate tech, which means it could be even harder and take even longer to get projects off the ground.

Ursula von der Leyen, President of the European Commission

The EU Update

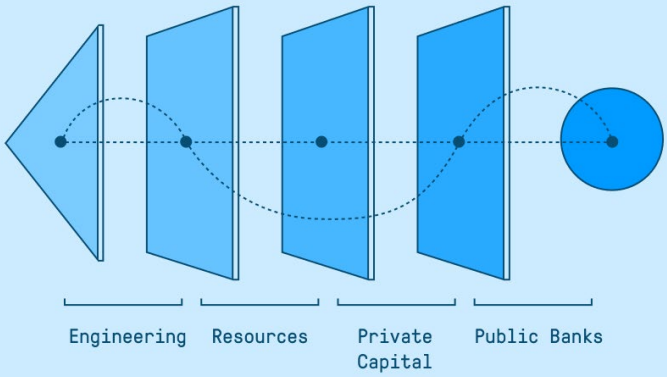
European Green Deal

In July, Ursula von der Leyen was re-elected President of the European Commission.

During her last five-year term, the Commission passed major new legislation under the banner European Green Deal. It's now time to implement these policies across all 27 member states.

Europe continues to be committed to its climate ambitions—and to deliver greenhouse gas reductions. Its leaders have been increasingly focused on clean energy production and clean-tech manufacturing. Not only is this good for the climate, but Europe also sees these sectors as crucial to maintaining regional security and economic competitiveness.

This shift has given rise to the Green Deal's successor program—"The Clean Industrial Deal"—which aims to accelerate investment and construction of climate tech projects and to close the gap between ambition and delivery.



01 Putting together the pieces:

On paper, the EU has everything necessary to succeed: world-class engineers, o an abundance of private capital, and public banks committed to climate like the European Investment Bank.The challenge going forward is to pull all these resources and strengths together to accelerate the scale-up and deployment of climate tech factories and projects in Europe.

That's why in Europe, we're laser focused on projects.

One way to pull together Europe's vast resources is by making the pieces want to come together. That starts by changing the incentive structure for climate tech. In addition to the Green Deal penalties on fossil fuels, there must be clear examples of how private sector actors can benefit from completing construction on clean projects.

Team members from Breakthrough Energy's Catalyst and Europe teams, Rondo, and the Energy Resilience Leadership Group

02

A triple win:

Already, we're seeing European climate tech projects achieve the triple win: a win for climate, competitiveness, and security. For example, by directly funding innovative projects like Rondo Energy's pioneering clean electric heat technology that will help Europe replace imported gas. Thanks to a €75 million investment via the EU-Catalyst Partnership, Rondo will build three projects across the EU.

These types of projects only get off the ground when there's a conducive, supportive ecosystem. In the case of the Rondo investment, for example, the projects were initially identified by the Energy Resilience Leadership Group, a "coalition of the willing" bringing together industry leaders, policymakers, and startups to quickly get climate tech projects off the ground.

03

Spotlighting cutting-edge cleantech:

But it's also about spotlighting cutting-edge climate tech solutions in Europe and the leading investors that can help these solutions scale into real projects. BE has been supporting the climate tech movement across Europe. Through Cleantech for Europe and national/regional hubs, we're advocating for policies that can make the "deal" part of the energy transition a reality.

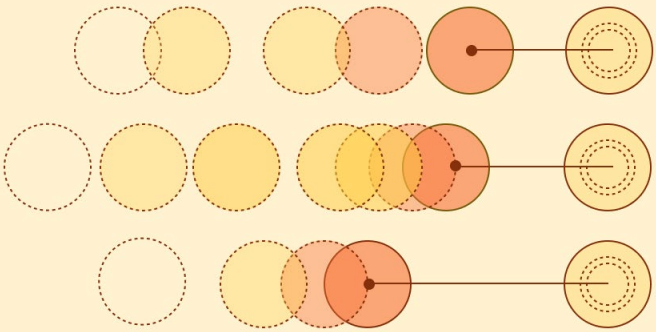
As the Clean Industrial Deal gets underway, we hope to see more such projects and collaborations, and will be on hand to make Europe the climate technology leader it aspires to be.

A New Labour Government

In the U.K., the July elections installed a new Labour government which has put the energy transition at the heart of its economic and growth policy proposals—a change from the previous Conservative government's approach.

Labour has committed to decarbonizing the U.K.'s power sector by 2030, five years ahead of the previous Conservative government's target. But the new government also appears to be looking at climate with a Chief Investment Officer's perspective. They're focused on securing the pounds necessary for meeting their current, legally binding emissions goals.

Keir Starmer, leader of the Labour Party, speaks to Labour Party members in Bollington, Cheshire, while on the General Election trail. Source: Flickr



01 **A clean innovation double down:**

The new Labour government says its goal is to "Make Britain a Clean Energy Superpower," with many of the projects situated in the country's industrial heartland, the area stretching from the Midlands to northern England.

One example is sustainable aviation fuel (SAF). The U.K. will soon require airlines to use 10% SAF by 2030 and 75% by 2050. The challenge will be SAF production: *Where will the investment come from?*

Breakthrough has been working with the Green Finance Institute, bringing together the necessary parties—government, investors, lenders, insurers, airlines—to get SAF production off the ground.

02 **New net-zero target gets an arrow:**

Labour's 2030 decarbonization target requires the country to accelerate the construction of clean projects. To speed things along, Labour is establishing GB Energy, a new government entity designed to leverage private finance in new technologies. They have also committed to establishing a new National Wealth Fund, to help unlock institutional investment for green infrastructure, such as ports, gigafactories, hydrogen, and steel projects.

While the 2030 target is ambitious, we believe it signals a clear commitment to positioning the U.K. as a leader in the global race to net-zero emissions.

03 **Re-planning:**

It took 19th-century workers about 13 years to build Big Ben. It takes almost as long for 21st-century Britons to build a new grid connection—often, a decade. The new Labour government has said it will drastically shorten these timelines and has already lifted the ban on new onshore wind projects.

Unlikely Bedfellows

A Final Thought

BE Founder Bill Gates visits Infinium's eFuels Facility in Corpus Christi, Texas

As the economics improve, the politics fade.

"If you want to see what the cutting edge of next-gen clean energy innovation looks like, it'd be hard to find a place better than Texas."

That was Bill's assessment after visiting the Lone Star State in March.

In a way, it's surprising: Texas is the birthplace of the modern oil industry.

How could it also be the birthplace of America's Clean Industrial Revolution?

The answer is that the skills from the old carbon-heavy industries apply to the new carbon-neutral one.

As Bill writes:

> Nearly half a million Texans work in the oil and gas industry, and their skills are directly transferrable to next-generation industries. This workforce will help form the backbone of the world's new clean energy economy, and it will cement Texas's energy leadership for generations to come.

Texas exemplifies a broader trend: When clean energy becomes economically competitive, the political debate shifts from "should we?" to "how can we?"

This shift in thinking is core to Breakthrough Energy's mission. We believe that achieving global net-zero emissions hinges on making carbon-free solutions as cost-effective as their carbon-intensive counterparts.

This economic imperative can unite diverse stakeholders—from environmentalists and investors to industrialists and entrepreneurs—creating a powerful coalition for change. As green premiums on clean go down, the world's net-zero coalition will grow.

Grand Challenges

The Annual Grand Challenge Update

Humanity emits around 52 billion tons of greenhouse gases (GHGs) every year, and if we want to build a clean energy future, then we need to reduce that number to zero. The first step is understanding where these emissions are coming from.

Five activities in the global economy account for 100% of all emissions.

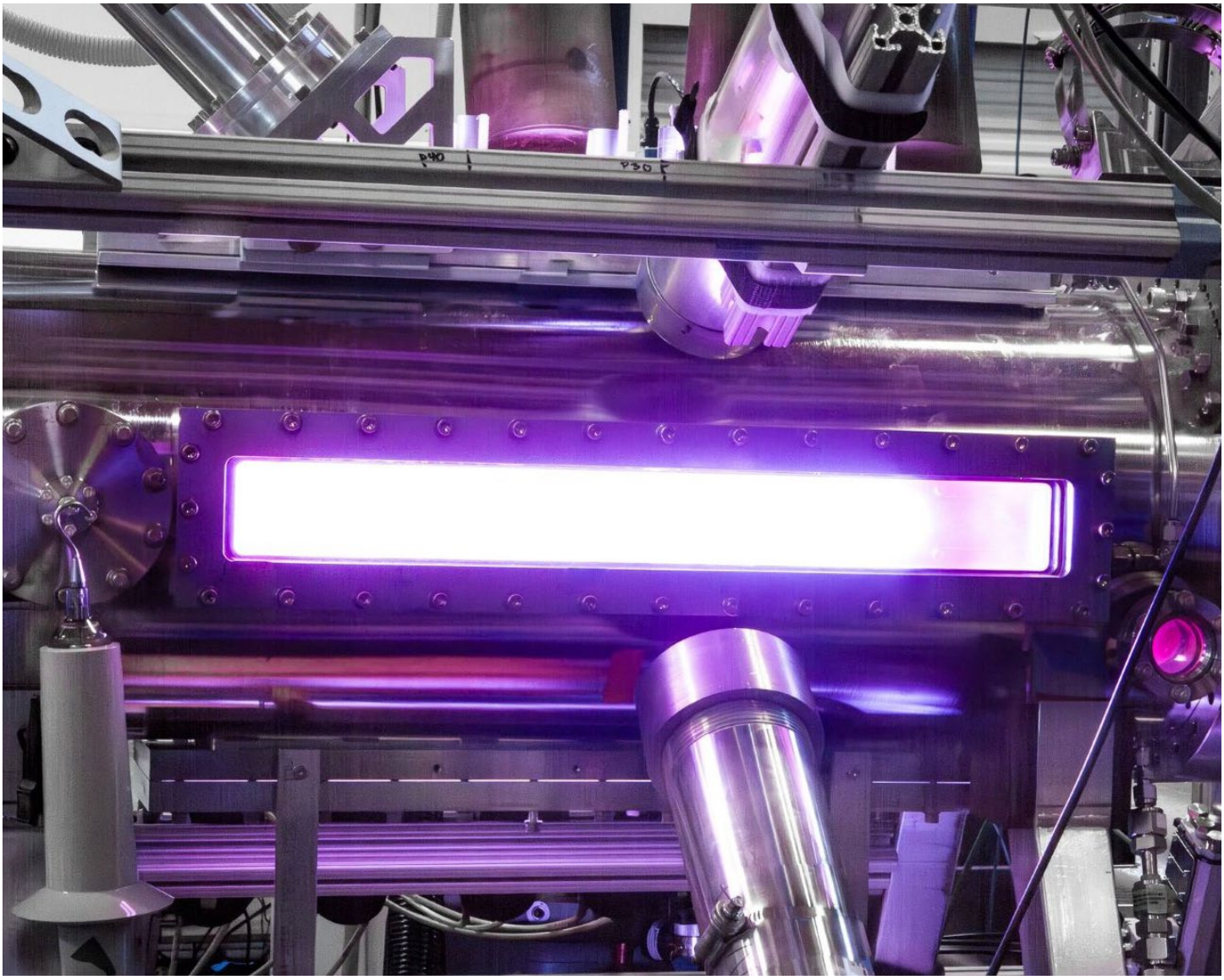
We call decarbonizing these activities: "The Five Grand Challenges." In this report, we'll discuss the progress being made in these areas. But if you want to take a step back and learn more about each sector, check out last year's State of the Transition.

Electricity

28% of global emissions

14.4 billion tons of GHGs

In 2024, climate tech companies hit major development milestones, showing how nascent technologies—from nuclear fusion to advanced geothermal—might one day produce a significant amount of clean energy.



But another story—maybe the *bigger story*—was the advances made in transmitting and storing energy. As we wrote in last year's report:

> In much of the world, power grids are either unbuilt or woefully obsolete, a problem that limits the impact every new wind turbine, solar farm, or nuclear plant can have.

This is still true—but less true than in 2023. Over the past 12 months, many Breakthrough-backed storage and transmission technologies have turned into real-life, steel-in-the-ground projects.

Look at Form Energy. They make affordable iron-air batteries that can store and dispatch clean electricity over multiple days. The U.S. DOE recently awarded them up to $150 million. Part of the money will go towards installing another manufacturing line at their West Virginia factory, which has helped bring 750 jobs back to a town whose tin mill recently closed.

Grand Challenges
Transmission

As energy use grows, our capacity to move that energy remains stubbornly stagnant with woefully outdated power grids that weren't built with renewable energy in mind.

Check out the Breakthrough Look Book↗

Marathon Fusion

FERVO ENERGY

Form energy

Manufacturing

30% of global emissions

15.3 billion tons of GHGs

For a fortnight in Paris this summer, over 14,000 Olympians called Athletes' Village home.

Most, we assume, were too busy focusing on gold, silver and bronze to realize Ecocem, in partnership with Vinci amongst others, had already locked up the prestigious (and definitely not made up by us) "green medal." The company's ultra-low carbon cement was used in constructing the village.

The manufacturing sector has been extremely difficult to decarbonize, but Ecocem is just one example of some remarkable progress made in 2024.

Terra CO2 is deploying their innovative version of clean cement while CarbonCure is approaching half a million metric tons of CO2 saved through its green concrete technologies. Meanwhile, Boston Metal has commercialized their technology in Brazil to recover high-value metals.

In the U.S., several industrial decarbonization companies, including BE-backed Brimstone, are due to receive new funding through the Inflation Reduction Act. Brimstone will use the IRA money to build a demonstration plant, which will produce 140,000 metric tons per year of ordinary Portland cement—with a carbon-free process. They'll use calcium silicate rocks to avoid more than 120,000 metric tons of CO2 emissions per year.

Corporate players are also getting involved and deploying these technologies. The fashion retailer Zara, for example, has launched a partnership with the textile recycling startup Circ to make climate-friendly, recycled clothes.

While we pursue innovation in making these materials, we've also seen progress capturing the carbon from their production through innovators like Mission Zero.

It's been such a big year for manufacturing companies that we're doubling down on this area in our report. Read more about our progress here:

Grand Challenges
Learn More

Cement and steel, the backbone of our built environment, are also climate culprits. But the industrial sector is seeing a revolution.

Check out the Breakthrough Look Book↗

CARBON CURE

MissionZero

TERRA CO2

ecocem

CIRCERO

Ecocem's ultra-low carbon Athletes' Village for Summer 2024. ↗

Circ Launches Second Collab With Zara — and Why It Matters ↗

Agriculture

19% of global emissions

9.9 billion tons of GHGs

Perhaps no profession has been impacted by climate change more than farming. Farmers around the world care deeply about this issue. BE not only believes farmers are the solution—we've also continued to support them in their mission to feed the planet.

Companies like Pivot Bio, Windfall Bio, and Rize are perfect examples of innovators building new technologies to help farmers do their jobs. These technologies are at different stages of development and deployment, but each of them holds tremendous promise for our partners in the farming industry.

For example, PivotBio is improving the efficiency and carbon intensity of the way farmers have been fertilizing crops for a century.

Before World War I, two German chemists,Fritz Haber and Carl Bosch, invented the industrial process to separate nitrogen atoms from the air and turn them into synthetic fertilizer. Without the Haber-Bosch process, it would be impossible to feed roughly half the world's population. But synthetic fertilizer is inefficient; wWhen it rains, most of it runs off into the water supply. And it's responsible for 2.5% of global greenhouse gas emissions.

But there's always been another way to capture nitrogen from the air and inject it into the soil. The microbes that live on the roots of plants do this naturally, and PivotBio has edited those microbes to enhance the effectiveness of this natural process. This way, the microbes themselves essentially become miniature fertilizer factories—without the GHG footprint, or runoff.

Check out the Breakthrough Look Book↗

Transportation

16% of global emissions

8.0 billion tons of GHGs

Greener cars are getting the green light, and may get a whole lot more power.

Over the next few years, new solid-state battery technologies could allow electric vehicles (EVs) to travel up to 500,000 km without any noticeable loss of range. Companies like WeaveGrid are helping utilities manage the charging needs of the growing EV fleet—the sales of which have quadrupled since 2021.

But we're not just focused on passenger vehicles. Some of the biggest culprits of carbon pollution are heavy-duty vehicles. That's why companies like Verne are finding new ways to tackle transportation decarbonization by developing high-density hydrogen storage systems. This technology can help decarbonize other, big culprits of carbon pollution like heavy-duty vehicles.

We've also seen new air technologies take flight, as corporations like American Airlines get more involved in securing offtake agreements for clean aviation fuel. Through our Catalyst and Ventures programs, we've invested in promising liquid fuels solutions like Infinium and Viridos. Meanwhile, ZeroAvia (they build hydrogen-electric engines for planes) has announced the completion of several flight tests, as well as new purchasing agreements with numerous airlines, including American Airlines and Ecojet. All of these technologies hold huge promise for decarbonizing the transportation industry.

Finally, innovative players like KoBold and Redwood are making progress on better mining and recycling processes, so countries can diversify their sources of the critical minerals necessary for batteries.

Check out the Breakthrough Look Book↗

Buildings

7% of global emissions

3.7 billion tons of GHGs

Cleaning up how buildings heat themselves in the winter and stay cool in the summer is probably the Grand Challenge that's decarbonizing fastest.

One reason for the progress: In 2024, several companies with the most cutting-edge technology moved past the prototype and pilot project stages. Their tech is ready for prime time and being installed across millions of square feet of new and existing construction.

Corporations are both buying and investing in climate tech—from LuxWall's vacuum-insulated windows to Aeroseal's fix for sealing leaky HVAC systems—because the economic case is obvious. Within a few years, these technologies pay for themselves with savings on energy bills, in some regions, IRA and utility incentives can lower that payback time to less than a year. In LuxWall's case, the company announced it would triple production to meet demand. They cut the ribbon on a new manufacturing plant in Michigan this year.

"Buildings" may be the smallest Grand Challenge.

It accounts for just 7% of the world's emissions. But that's just one way to slice it. If we include the carbon footprint of the construction materials and the energy used to power HVAC systems, buildings account for ~40% of emissions.

"The built world" is an enormous lever for decarbonization, and in 2024, the world gave that lever a strong pull. The planet's largest purchaser—the U.S. Federal Government—ramped up its Buy Clean initiative, which calls for using lower-carbon materials and construction processes.

There's a thriving ecosystem of companies innovating in the area like CemVision, which makes net-zero cement by using mining and industrial byproducts. There's also Vantem, which has built three million square feet of energy-efficient and affordable homes and schools, all using cost-effective modular construction.

Check out the Breakthrough Look Book↗

Manufacturing

The Rebar Revolution

Heavy industry is lightening up as innovators develop new carbon-free ways to manufacture cement and steel—the backbone of our built environment.

Walk outside and look around you. It may not be New York, but you're still likely surrounded by a concrete jungle.

The main ingredient in that concrete is cement, the most widely used man-made material in the world. Together, cement and steel production make up 10% of global greenhouse emissions.

The ubiquity of these materials is just one reason why manufacturing is the hardest sector to decarbonize. But here's the good news: It's also the one that's seen arguably the most exciting progress over the last year—on policy, innovation, and actual deployment of technologies.

New Policies

The Industrial Demonstrations Program

Let's start on the policy side. Earlier this year, as part of the Inflation Reduction Act, the U.S. Department of Energy announced $6 billion in funding for innovative clean industrial technologies through the Industrial Demonstrations Program (IDP). A number of companies with promising technologies received capital from this critical funding, which represents the single largest federal investment for industrial decarbonization.

In addition to more public funding, we've seen an increasing focus on procurement contracts. Since both steel and cement are "merchant markets," they have trouble securing long-term offtake agreements, making it harder to build new factories and begin production. This has long been a barrier in this space, even before the development of clean industrial technology. The Federal Buy Clean Initiative is helping solve this problem, allocating funds for the U.S. government—the country's biggest purchaser of construction materials—to buy more clean materials.

While we need to continue cleaning up the process of making these materials, we also need to clean up the process of buying them. If you want to lose weight or eat healthier, you may start looking at the nutrition labels on the food you eat. The same goes for buying clean materials—in order to lower your carbon footprint, you need to know how much embodied carbon is in materials you're using to build.

That kind of transparency has traditionally been lacking in this space. That's why the Bipartisan Infrastructure Law's recent funding for Environmental Product Declarations is so important. Like nutrition labels, these declarations allow government and private consumers to make more informed decisions about which products to purchase.

While we need to continue cleaning up the process of making these materials, we also need to clean up the process of buying them.

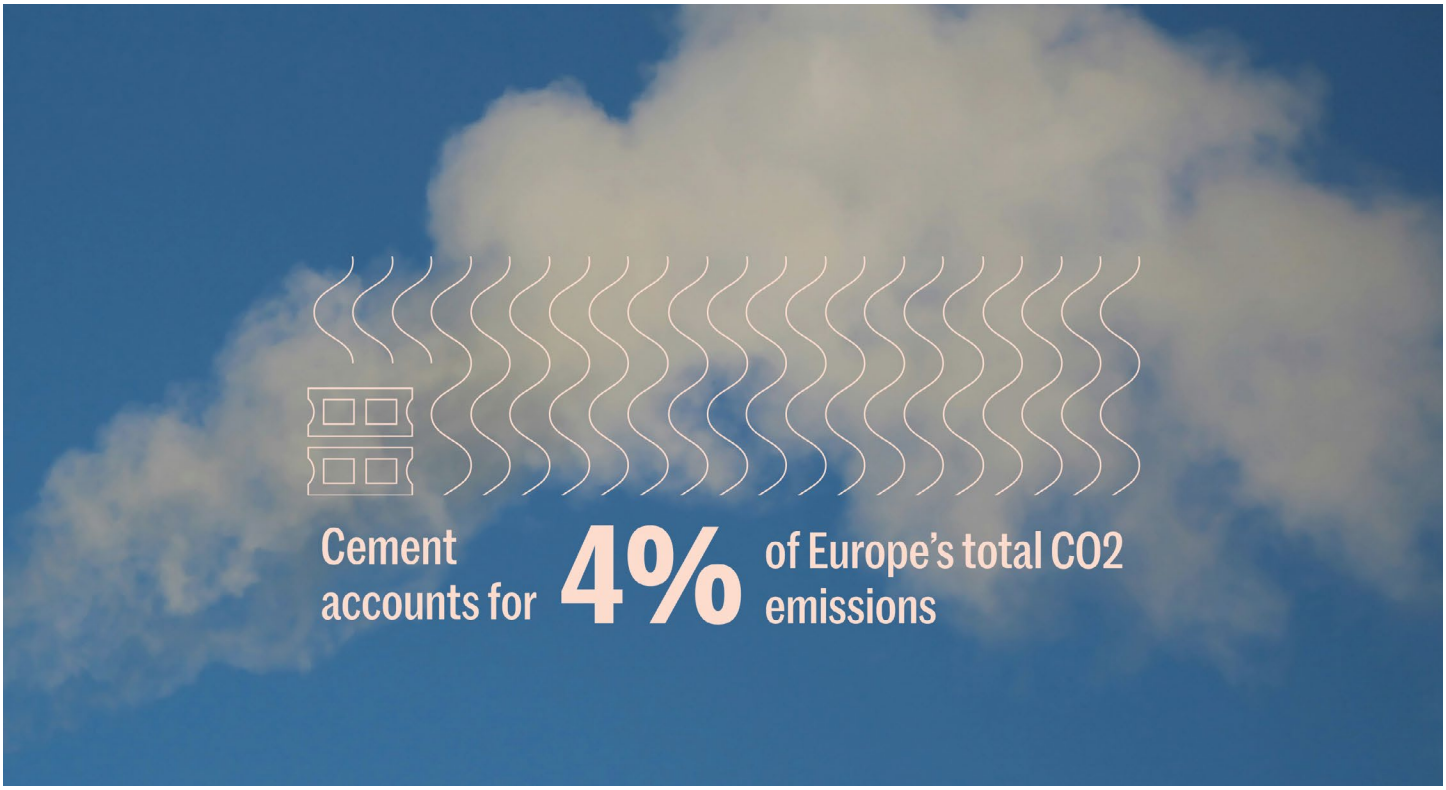
None of this happened in a vacuum. It happened, in large part, because of a willingness and even demand from customers in both government and the private sector to buy clean industrial materials. If we can continue to spur that interest and demand through more "Buy Clean" policies, we can keep making progress.

Unfortunately, the advancements we've seen in the U.S. over the last year have not translated globally. While Europe, for example, has made progress in end-use applications, such as including regulation on whole-life carbon in new buildings, the region remains stagnant in its decarbonization goals for cement, which accounts for 4 percent of its CO2 emissions.

Last year, BE helped launch the Alliance for Low-Carbon Cement and Concrete, a group of companies and NGOs from across the industrial ecosystem, to spur action on cement in the EU. We have technologies that are ready to scale right now—we just need more movement and urgency from European lawmakers to support performance-based standards, "buy clean" policies, innovative financing, and a level-playing field with incumbents.

Product Impacts	Declared Unit: 1 m^3 of 10,000 psi concrete at 28 days
Global Warming	445kgCO_2eq
Emitted	460kgCO_2eq
Sequestered	-15kgCO_2eq
Ozone Depletion	0.000kgCFC11eq
Acidification	2.96kgSO_2eq
Eutrophication	0.61kgO_3eq

Example of an Environmental Product Declaration "nutrition label" | Source: Building Transparency



Decarbonizing Heavy Industrials

We've also seen broader acceptance, over the past year, of innovation's critical role in decarbonizing heavy industries—not just through carbon capture and sequestration, but also through new technologies and solutions. And this innovation can be found across the three phases of growth in the climate tech space, what we often refer to as the three D's: discovery, development, and deployment.

Last Year's Annual Report on Carbon Management ↗

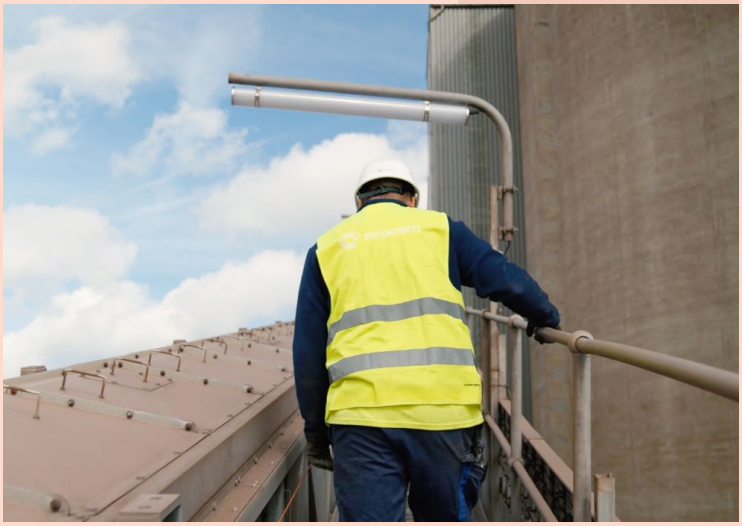
Manufacturing

Ecocem

BE-backed companies like Ecocem, for example, are delivering scaled solutions that can actually be deployed today. In fact, Ecocem is currently supplying the Grand Paris Express construction work, Europe's largest transportation project, and the UK's HS2 high-speed rail extension. Ecocem's low-carbon tech was also deployed this summer in Paris to help construct the Olympic Athletes' Village. And we're on the verge of even more progress in this space with Ecocem's groundbreaking globally scalable ACT cement technology, which recently received a European Technical Assessment, an independent evaluation that opens the door for Ecocem to bring its innovation to European markets.

Rigorous trials in 2024 across a number of job sites have demonstrated that concrete made with ACT can deliver a 70% reduction in CO2 compared with the average European cement blend, while maintaining the concrete's workability, strength, and durability without excessive costs. And it won't be long before it comes to market: Ecocem plans to supply the technology commercially in Europe in 2026.

Ecocem
Cement

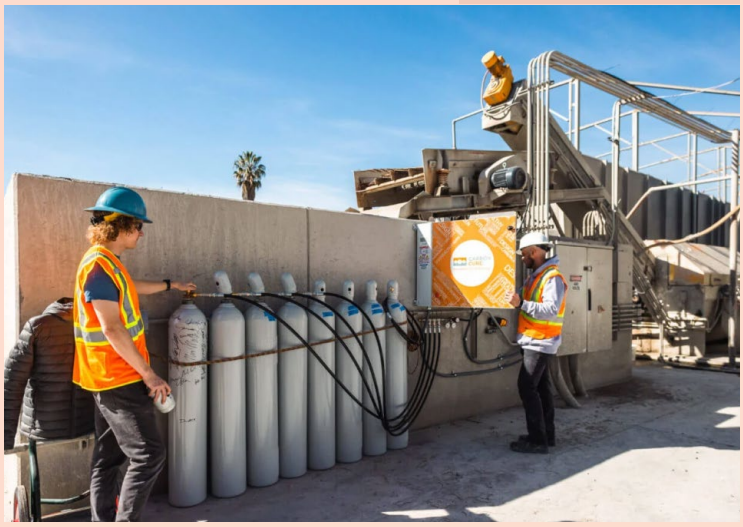


Manufacturing

CarbonCure

Concrete made with CarbonCure's technology is also immediately deployable and is already operating at scale in more than two dozen countries. Over seven million truckloads of CarbonCure concrete have been delivered, including nearly two million in just the last year alone.

CarbonCure
Concrete



Manufacturing

Terra CO2

Terra CO2 is another company innovating in this space. Their version of clean cement has been fully developed, and Terra CO2 is ready to deploy it in partnership with construction materials firms. In May, Terra CO2 secured a permit to build a new plant in Dallas, with construction slated to start by year-end. The facility, when completed, will let concrete makers produce their own cement substitute, potentially using more of it than traditional alternatives and reducing the need for regular cement. And like CarbonCure's technology, it's a drop-in solution that's ready to be integrated into the supply chain right now.

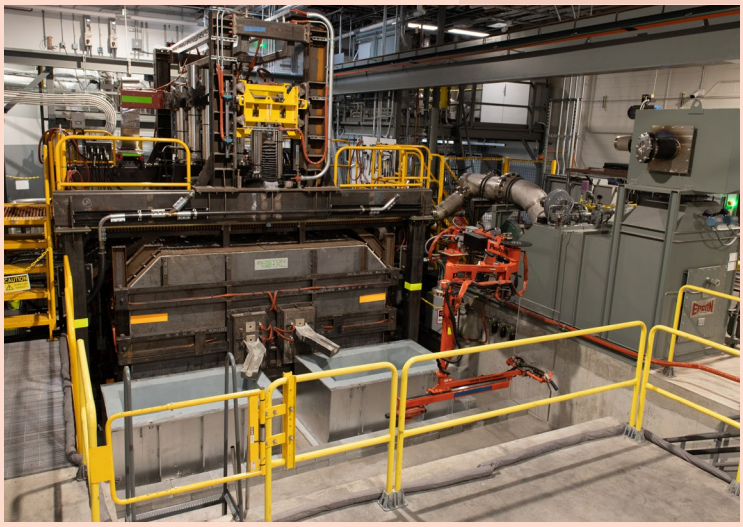
Terra CO2
Cement

Manufacturing

Boston Metal

Boston Metal is one of the companies that is tackling the steel side of this equation and it plans to license its technology to steelmakers for the production of green steel. Boston Metal's technology was deployed commercially for the first time this year in Brazil to produce high-value metals and revenue from its high-value metals business supports scaling up their steel decarbonization technology.

Boston Metal
Steel



Manufacturing

Brimstone

Other BE companies in still-earlier stages of development are already making significant progress. For example, Brimstone, a company we highlighted last year that significantly reduces the carbon footprint of cement, was selected for new IDP funding from the U.S. government.

Brimstone
Cement

Of course, manufacturing is a massive category that covers all the ways we source and make the many things we use across the economy. Steel and cement are a major piece of the puzzle, but so are other products like hydrogen and chemicals, as well as the way we power our manufacturing, including industrial heat and the potential to electrify manufacturing processes. Industrial heat companies like Antora and Rondo, and grid-scale storage companies like FourthPower are already negotiating projects and could play a critical role in helping decarbonize this sector.

Building the Infrastructure

We've made remarkable progress. But we still have work to do. And we could face a few obstacles in the coming year that can have lasting impacts, especially in the U.S. For example, the recent Chevron decision by the U.S. Supreme Court has the potential to hamper the efficiency and effectiveness of federal agencies in implementing new climate policies.

Even assuming that today's policies remain untouched, we still have to continue investing in the supply of low-carbon technologies, spurring demand for low-carbon products, and supporting transparency for industrial materials.

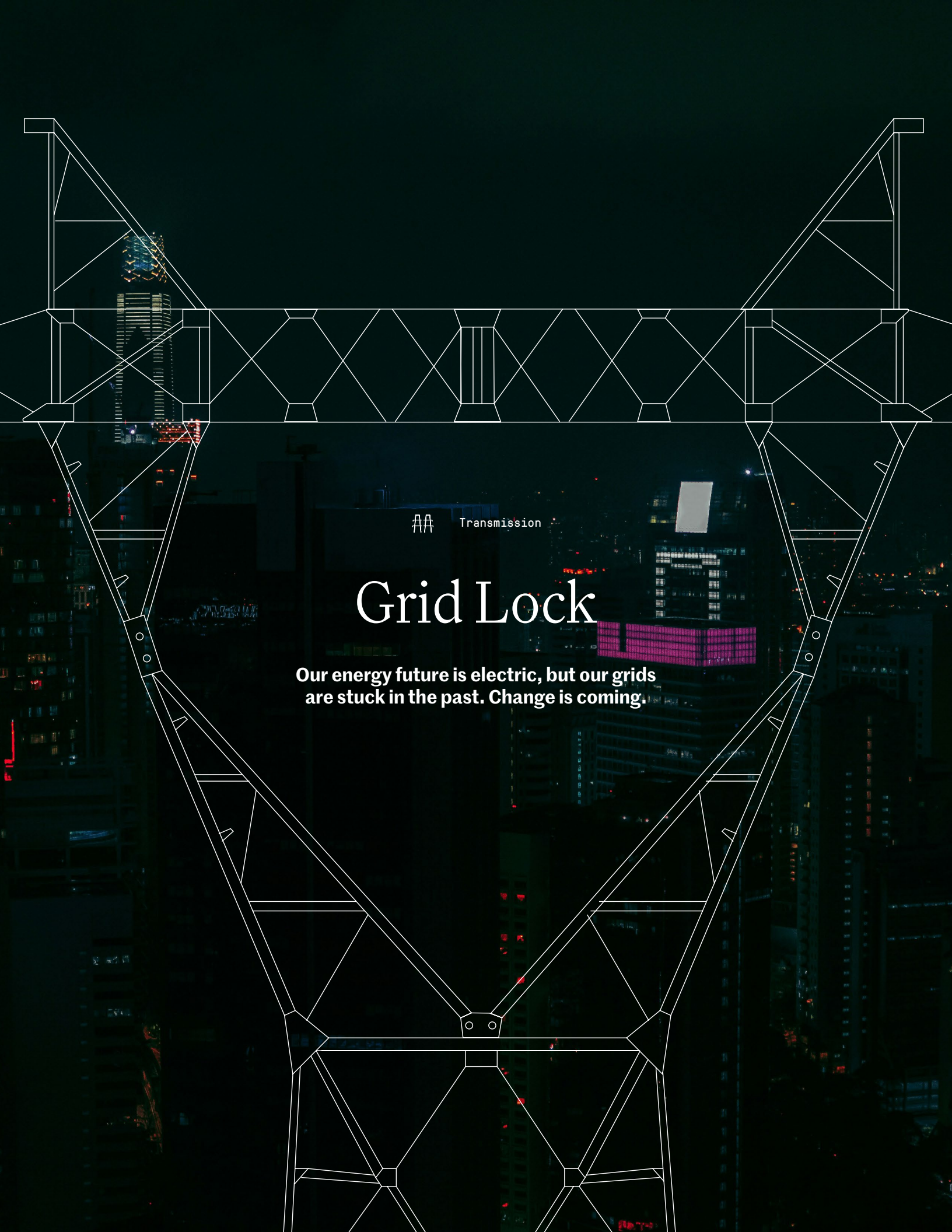
But there are two more wrinkles here. First, we have to address embodied carbon in trade globally. When one country receives raw materials from others, they need to account for the emissions in the production of those materials as well, otherwise they risk undermining all the investments they're making at home. But this can be accounted for; Europe, for instance, is tackling this problem with its Carbon Border Adjustment Mechanism.

Second, we have to build enabling infrastructure for all of these technologies to work. That means new transmission lines, as we discussed in the transmission section. It means further investment in carbon capture and sequestration, since some manufacturing sectors might take a long time to fully decarbonize. And it means leaning into other tools, like clean hydrogen, which could help clean up heavy industry through a variety of ways—from being used as chemical feedstock for steel production, to the ammonia that can power the shipping of industrial materials.

To cut emissions, use this Swiss Army Knife ↗

Grand Challenges
Transmission

As energy use grows, our capacity to move that energy remains stubbornly stagnant with woefully outdated power grids that weren't built with renewable energy in mind.



Transmission

Grid Lock

Our energy future is electric, but our grids are stuck in the past. Change is coming.

We need to electrify our economy as much as possible to hit our net-zero goals. But as our energy use grows, our capacity to move electricity remains stubbornly stagnant. That's because global power grids are woefully outdated.

In the United States, many of the power lines you see today were built in the 1960s.

What's more, these grids weren't built with renewable energy in mind. As we explained in last year's report, our system of railroads and pipelines was designed to move fuel over long distances to centralized power plants, where that fuel is turned into electricity and transmitted over short distances to the cities that need it. This system doesn't work for wind and solar, which are intermittent and often far from where people live.

That means we're facing a significant bottleneck. In other words, we're creating lots of energy, but we don't have enough infrastructure to store and move it.

In order to meet both our climate goals and the coming energy demand, we desperately need to update our grid, build more transmission lines, invest in advanced transmission technologies, and, ultimately, more than double the size of the grid by 2050.

The Transmission challenge ahead
BE Newsroom
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Last Year's Annual Report
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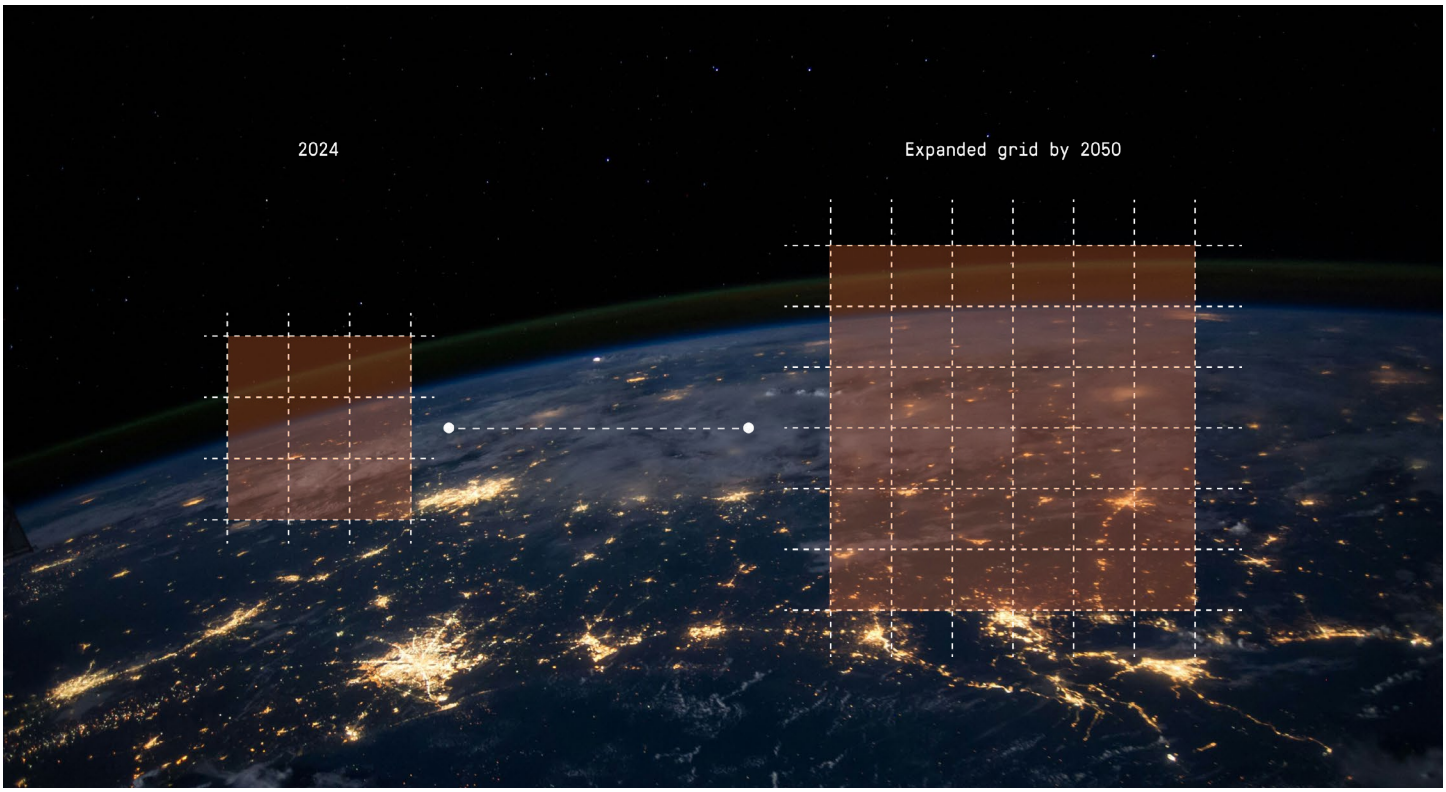


On Hold

The Transmission Bottleneck

In the grand scheme of the energy transition, the consequences of the transmission bottleneck cannot be overstated.

Right now, it's hindering our ability to bring new innovations to market and bring down green premiums for these technologies, because they're stuck in interconnection queues for five to seven years before even getting on the grid. Deploying new grid and transmission technologies sooner and more efficiently will require a cross-regional, proactive build-out of transmission in countries around the world.

We've made progress in some of these areas over the last year. For example, we've seen growing interest in many of the technologies we highlighted in our 2023 State of the Transition Report, including advanced conductors and high-temperature superconductors for electricity distribution and transmission, as well as grid-enhancing technologies such as dynamic line ratings. BE companies like VEIR and TS Conductor continue to raise tremendous amounts of capital; VEIR is on track to deploy its first commercial project in 2026 while TS Conductor has installed more than 1,000-kilometers of technology over the past eight years. Many of the company's biggest investors are also its biggest customers.

Electricity

VEIR

VEIR's systems combine superconductors with a novel cooling system architecture that result in the first cost-effective solution that can deliver 5-10x the power over the same transmission corridor, above or below ground, over long distances.

Learn More

Electricity

TS Conductor

TS Conductor products allow transmission & distribution grid operators to be active participants to the energy transition – by reducing line losses and accelerating the integration of wind, solar and battery storage – while leveraging existing infrastructure assets.

Learn More

Reconductoring lines with advanced conductors is an effective way to double the capacity of transmission lines while utilizing existing transmission towers, structures, and rights-of-way—saving time and money. Advanced conductors represent an innovative solution that can help us meet near-term load growth. However, it's not a substitute for the development of new transmission lines, which are necessary to access abundant but remote wind and solar resources, as well as nascent technologies like next-generation geothermal.

Embracing Innovation: Transforming the Grid for a Sustainable Future

↗

The Three P's of Transmission

Planning, Paying, and Permitting

Advancing U.S. Transmission Deployment: Navigating the Policy Landscape ↗

There are three major regulatory phases to building out new transmission lines, which we often call the "Three P's of Transmission": planning, paying, and permitting—all of which come with their own challenges and needs for policy reform.

In the U.S., those challenges have existed as long as there's been a grid. And the solutions we need will require us to reimagine a century of transmission policy.

Fortunately, the last year has brought progress. The Federal Energy Regulatory Commission (FERC) recently issued arguably the most significant regulatory milestone concerning interstate power lines in three decades.

This new rule, known as Order No. 1920, will help modernize our grid through three major requirements for transmission providers.

01

Forecast

First, it requires providers to forecast energy needs two decades into the future and update their plans on a five-year basis.

02

Reliability

Second, it requires utilities to value reliability and cost savings when splitting the cost of transmission lines.

03

Scope

Third, it requires transmission providers to consider broadening the scope of potential solutions they can use, including advanced conductors, to upgrade our grid.

By addressing major barriers to planning and paying for new transmission, the FERC rule is a major step forward that will transform the way the U.S. builds and pays for regional transmission.

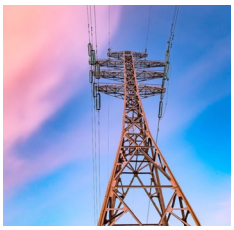
The next big challenge will be doing the same for interregional transmission lines that cross different parts of the country, arguably an even more important task to bolster grid reliability and lower energy costs and emissions.

We also have work to do when it comes to permitting. Unlike natural gas pipelines, siting authority over transmission lines is bifurcated between federal and state authorities. This underscores the critical need for permitting reform to streamline the approval process for transmission lines considered to be in the nation's interest. In the United States, lawmakers have put forth a bipartisan bill to accelerate permitting for critical energy projects.

Permitting delays have long plagued our ability to build out transmission capacity. For example, as we noted in last year's report, one transmission line between Wyoming and California took 17 years to get permitted. And just this summer, an Illinois appellate court reversed approval of a 780-mile, decades-in-the-making transmission line from Kansas to Indiana.

These problems are not unique to the United States. Europe, for example, faces similar hurdles. Like the U.S., Europe has a deeply antiquated grid that has suffered from years of underinvestment. Meeting the EU's ambitious economy-wide climate goals will require an investment of more than €500 billion per year above and beyond historical spending rates, as well as a significantly more efficient and simplified permitting process.

FERC Just Finalized the Most Historic Transmission Rule This Century ↗



Transmission lines extend into the distance

Europe's Grids Are Not Up To Grade ↗

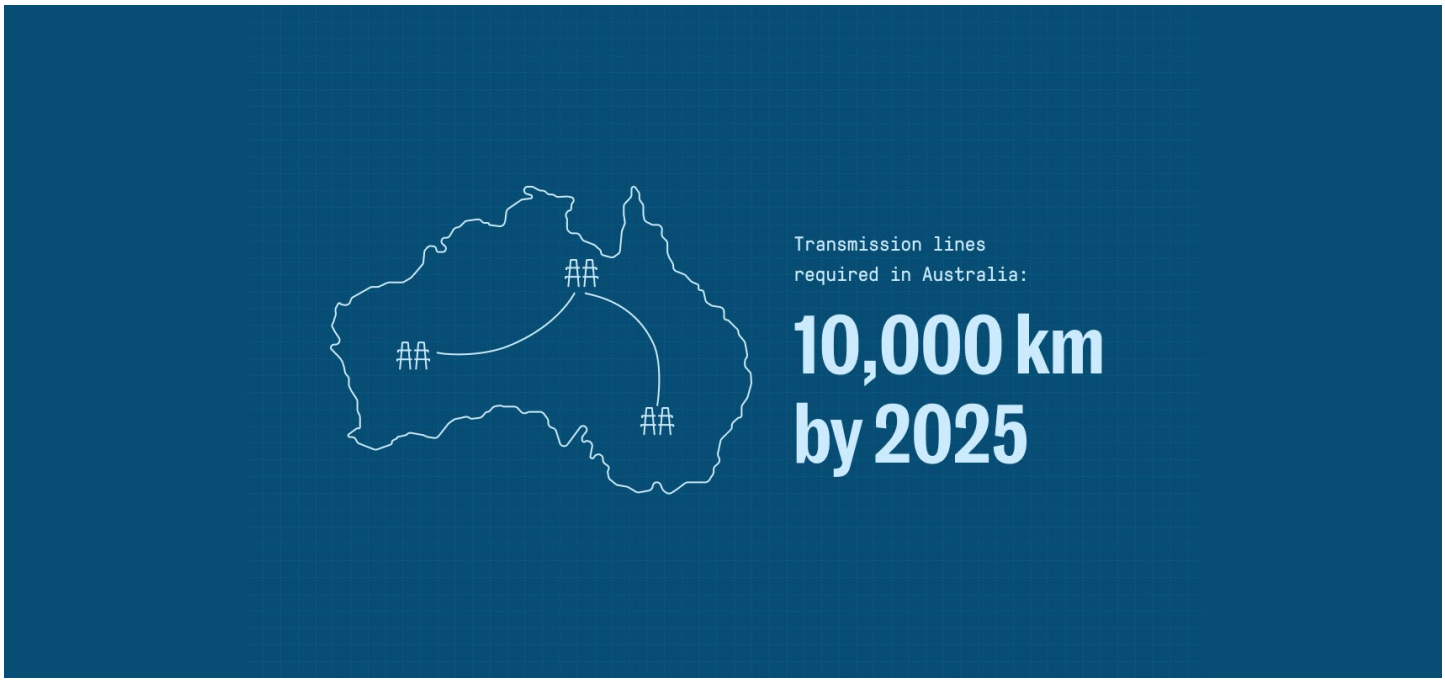
In November 2023, the European Commission unveiled a 14-point Grid Action Plan to overhaul the EU's electricity grids, focusing on faster deployment and digitalization to support the renewable energy transition. This sets a high level of ambition and lays out the work for the years to come, but the challenge remains in turning this vision into reality.

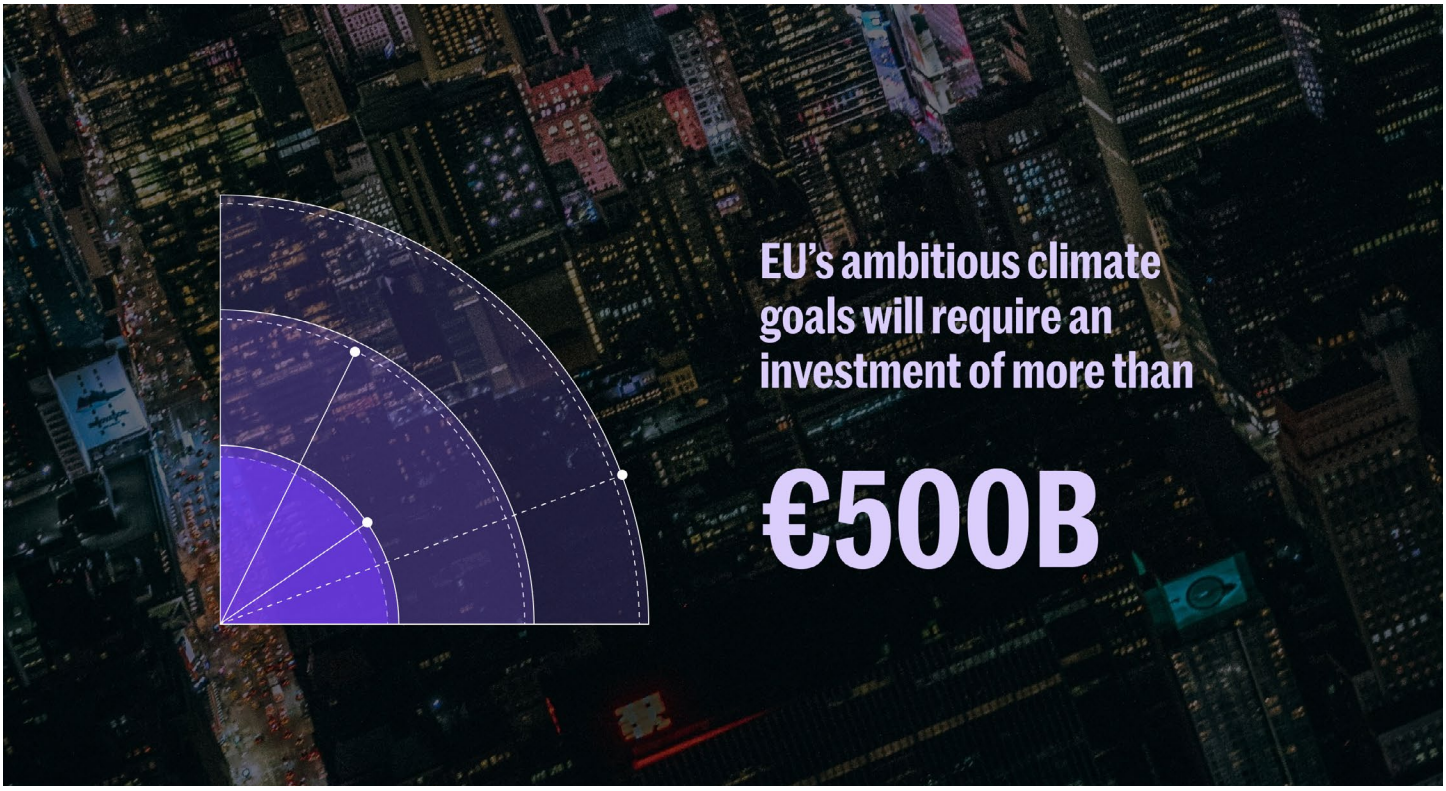
Our recent analysis showed that grid-enhancing technologies and innovative solutions can significantly strengthen, accelerate, and optimize the EU's electricity transmission and distribution networks if implemented, as we anticipate an increased focus on power grids in the new political cycle.

Prospects for innovative power grid technologies ↗

It's the same story across the Asia Pacific—from the vast distance of new transmission lines required in Australia (10,000 km / 6,200 miles by 2050), to the incompatible and congested grids in Japan, to the need for power to be transmitted from ASEAN countries with more abundant access to renewable energy to high-volume energy users like Singapore.

While the ASEAN Power Grid project has existed for decades, it's fraught with a lack of political will, insufficient funding, and the tendency to default to the "lowest common denominator" (i.e. the baseline of what all ASEAN countries are willing to commit to creating).





Grid Unlocked

An Operating System for the Grid

In addition to constructing new lines and enhancing current ones, we have to build new ways to model and operate our grid. In the past, operating the grid has been pretty straightforward: model the supply and demand, and then dispatch generators accordingly. Intermittent resources have made this process significantly more complicated, with the potential for weather interruptions, as well as a need for more granularity in the long-term planning process and a greater ability to store energy and transport it over much longer distances.

To take full advantage of these new resources and to meet our decarbonization goals, we need granular, fast, and effective grid modeling. More importantly, we need to be able to better connect the different types of grid models that provide critical data to plan investments in new transmission projects, help bring better products to market and reduce the risk of bottlenecks.

At Breakthrough Energy's Summit in London, we announced our new grid modeling project, an open-source platform that will enable any part of the world to build a 21st century clean grid by improving grid planning, forecasting, and integration of clean energy.

Let's be clear: This is a good thing. Increased load growth is a positive result of economic competitiveness and growth. Energy is prosperity, and we should be trying to match this expansion, not minimize it. We've said it before and we'll say it again: There's no transition without transmission.

Our goal is to build a platform that will act as an "operating system" for grid decarbonization, adaptable to any existing models and regions for comprehensive and effective planning.

Ultimately, no one solution will solve the transmission problem. We have to do all of these things simultaneously—reconductoring or replacing old wires, building out new lines, reforming our permitting processes, and improving our grid planning and modeling.

What we can't do is stop or slow down. Our energy load is rapidly increasing with the advent of artificial intelligence, consumption by emerging markets, and new, electricity-dependent technologies that will help decarbonize major industries. Let's be clear: This is a good thing. Increased load growth is a positive result of economic competitiveness and growth. Energy is prosperity, and we should be trying to match this expansion, not minimize it. We've said it before and we'll say it again: There's no transition without transmission.

Over the next year, it will be critical for policymakers in the U.S., Europe, Asia, and around the world to expand transmission and make it easier to build the grid we'll need for the future. And it's incumbent on private investors to be involved every step of the way, supporting new transmission and distribution technologies to help meet our net-zero goals.