TECHNOLOGY BRIEF

The New Industrial Logic of Climate Solutions

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Most climate funding flows to familiar technologies that scale linearly but deliver little. The real breakthroughs lie in high-leverage solutions that feel improbable—yet unlock multiple benefits across energy, food, water, and carbon. This report maps those overlooked opportunities, explains why they matter, and shows how new sensing infrastructure can turn theory into scalable industry. The future belongs to compounders.

FROM FARM AND FAITH TO FOSSIL FINANCE

Human civilization hasn't always been fixated on production and consumption. For millennia before the steam engine, society's pursuits could be summed up as farm, fight, pray—tilling the soil, waging wars, and seeking meaning. The industrial age rewrote these priorities. Today our global civilization is largely about invest, produce, consume—pouring capital into growth, churning out goods, and devouring resources. This single-minded drive propelled living standards and population to unprecedented heights. It also pumped a staggering amount of carbon into the sky.

By the late 20th century, the Keeling Curve of atmospheric CO_2 began its sharp ascent. Now, climate models warn that the trajectory of industry could heat the planet by around 3°C by 2100, with worst-case scenarios exceeding 4°C. No one seriously disputes the imperative we face: we must pull far more carbon out of the air than we emit—on the order of billions of tons per year, according to the IPCC. The question is how to do it practically, amidst a landscape tangled by science, engineering, markets, policy, and public opinion.

It's easy to feel paralyzed by this multi-dimensional complexity—an unaccountability sink where everyone and no one is on the hook. Yet humanity responds to big problems as it always has: break them down into solvable bits. In that spirit, we can simplify the climate solutions space into two fundamental axes. One axis covers what conventional wisdom says *will* work if we throw enough money at it. The other covers what most assume *won't* work—at least not soon—but would change the game if it did. This rough division brings surprising clarity. It lets us map today's efforts and, more importantly, spotlight where we should focus next. (Note: I'm looking beyond mature options like wind or solar; those are already scaling as commodities. My concern here is the frontier of global-scale action.)

AXIS ONE – MORE MONEY, MORE OF THE SAME

Call the first axis Linear Scaling, or perhaps Conventional Bet. It represents climate solutions that inspire confidence in investors by feeling familiar: the more cash you pour in, the more they'll scale.

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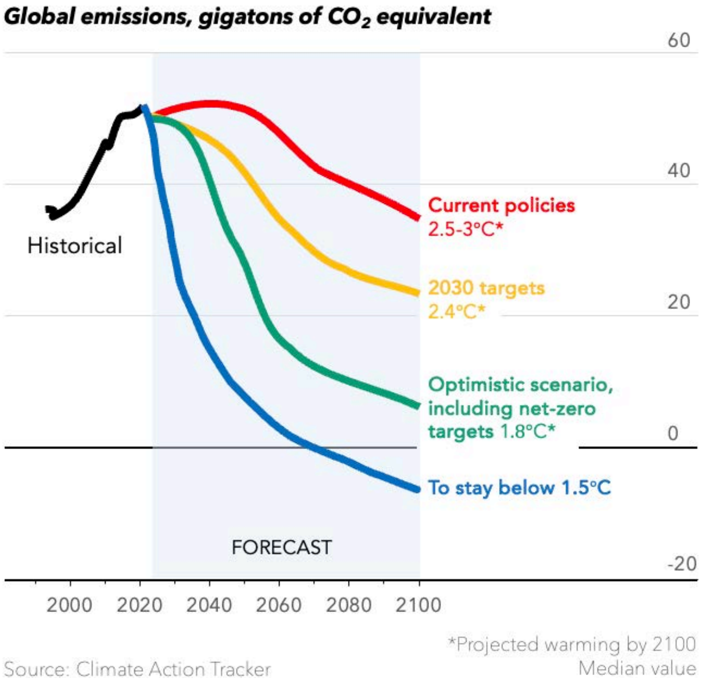
Many venture capitalists pride themselves on "exponential" thinking, yet they often flock to ideas that are actually incremental extensions of today's technology. They assume climate impact is just an engineering project away—a prime example of the Dunning–Kruger effect, where ignorance breeds overconfidence. With abundant hubris (and funds), investors have rushed into a slate of high-profile decarbonization ventures on this axis.

Direct Air Capture (DAC) is a case in point. VC firms and even government programs have poured hundreds of millions into DAC startups; one company, Climeworks, snagged $650 million in a single 2022 funding round. The premise is straightforward: to capture more carbon, build a bigger fan. Unfortunately, pulling CO_2 from ambient air—just 0.04% of the atmosphere—is incredibly dilute and energy-intensive. Even the largest DAC units today only capture a few thousand tons of CO_2 per year, a trivial drop in the 40-billion-ton bucket of annual emissions. The physics is unforgiving: one analysis found that removing the world's CO_2 output via DAC would consume nearly 450 exajoules of energy—in the same order of magnitude as all global energy production. In other words, DAC risks an exercise in costly futility, trying to vacuum a trace gas that is, while dangerous for climate, vanishingly thin in the air. Even optimists concede current DAC costs hover around $500–$1,000 per ton, and developers hope to merely get down to the $400s by 2030. Meanwhile, every kilowatt of renewable power spent running a DAC machine is a kilowatt not replacing a coal plant. By one estimate, using all the renewable electricity generated today for DAC would avoid more emissions if it were used to displace fossil power instead. In short, the opportunity cost is hard to justify.

Ultra-Deep Geothermal is another Linear-Scaling favorite. If energy is needed, why not drill deeper for abundant heat? Ambitious startups are pursuing superhot rock geothermal, using novel drills (from plasma torches to millimeter-wave beams) to bore down 10–20 kilometers. The vision is seductive: limitless 400°C heat for power plants anywhere on Earth. This has attracted significant investment—Eavor and Quaise Energy have raised hundreds of millions of dollars to drill. The concept may prove out in time, but it faces a long road. No one has ever drilled even half that deep in hard crystalline rock; the Soviet record is about 12 km, achieved over two decades of effort. Reaching "superhot" zones reliably means solving uncharted engineering



problems in extreme conditions. It's a worthy quest, but not one likely to deliver climate results on venture-capital timelines. *Per aspera ad astra*, as they say—through hardships to the stars (or in this case, Earth's mantle).

Then we have the dream of bioengineering the oceans to fix carbon. Companies like Running Tide proposed growing masses of kelp or algae and then sinking them to the ocean floor, effectively using marine biomass as a CO_2 ferry to the deep sea. This idea received tens of millions in funding—Running Tide raised over $50 million from investors and even secured offtake deals with buyers like Shopify. On spreadsheets, the carbon math looked favorable. In practice, it ran into biological reality. Early trials struggled with growth and unintended effects, and scientific critics pointed out ecological risks of altering ocean food webs. By 2024, Running Tide went belly up, having sequestered only about 25,000 tons of CO_2 and failing to find a viable business model. Nice on paper; much harder in the wild blue sea. It's a sobering reminder that crossing from petri dish to planet-scale often reveals gaps that no cash infusion can immediately bridge.

I could add a few more colors to this palette of well-funded, under-delivering solutions—remember Nikola? The much-ballyhooed "rainbow of hydrogen"—green, blue, turquoise, pink—has seen a frenzy of investment as folks try to repackage an old energy carrier as a new climate savior. Hydrogen *will* have roles to play, especially green hydrogen made from renewables and rock-trapped reserves. But the current hype (a hydrogen economy for home heating, trucking, aviation fuel, and so on) glosses over fundamental inefficiencies and infrastructure hurdles. As with DAC, a hard truth lurks: using renewable electricity to make hydrogen, only to turn it back into electricity or motion later, wastes most of the energy. In many cases, it's wiser just to use clean power directly. Nonetheless, money keeps flowing into hydrogen ventures of every color, often ahead of proven demand.

In summary, Axis One solutions share a common flaw: they overpromise and underdeliver in the near term. They assume climate impact can be linearly bought by scaling up a prototype—a bigger fan, a deeper drill, a larger algae farm, or a hydrogen supply chain. To be clear, these ideas aren't without merit. Some, like deep geothermal or certain hydrogen applications, may indeed work out over longer timelines. But so far, they have soaked up outsized attention and capital in relation to the results achieved. This hasn't stopped investors from finding greater fools to buy in at a markup—the classic venture capital pass-the-parcel game. However, the climate can't be gamed indefinitely. Eventually, the real world intrudes. As one energy analyst quipped, the climate-tech sphere has seen its share of a bubble, and bubbles do burst. Betting solely on linear scaling solutions is starting to look, in the cold light of 2025, like a good way to go linearly into a very hot future.

AXIS TWO – UNTHINKABLE, UNTIL IT'S NOT

Now pivot to the second axis. Call it Frontier Breakthroughs or maybe Compounders—solutions that *shouldn't* work (and usually don't), but if they did, they would rewrite the rules. This is the rarefied realm of fundamental science pushing into industry, of hard engineering laced with decades of broken dreams. It's psychologically and financially brutal territory. Many concepts here die repeatedly at the altar of physics or economics. Yet this is also where, every so often, a true world-changer emerges—a pearl in the oyster of innovation. The initiatives on this axis won't attract your casual VC tourist; they require patience and resilience. But any one of them could bend the global emissions curve in a profound, exponential way. Crucially, these solutions tend to yield compounding benefits across sectors, not just single-dimension gains.

Consider nuclear fusion—the poster child of eternal promise. Fusion energy has been "thirty years away" for at least sixty years now. Skepticism is warranted. And yet, quietly, fusion research has advanced. Private fusion startups and national labs alike are inching toward net energy gain. If—and yes, it's still a big if—fusion power becomes commercially viable in the next two decades, the payoff is stunning. We would unlock essentially limitless zero-carbon energy. Entire industries would be electrified without fossil fuels. Imagine electricity so abundant and cheap it undercuts coal by orders of magnitude. Fusion advocates talk of getting well below $50 per megawatt-hour, maybe even under $20, once technology matures—far cheaper than most grid power today. That would mean clean energy not just equal to current costs, but dramatically lower. The effects would radiate outward: transportation, heavy industry, desalination—all could run on near-zero-cost clean heat and power.

Fusion isn't alone in this category; geologic hydrogen offers a similarly wild card. Recent geological surveys suggest pockets of natural hydrogen gas (strangely dubbed "white hydrogen") trapped in certain rock formations. If substantial reservoirs exist and can be tapped, this would be a native source of zero-carbon H_2 fuel—no carbon, no combustion, no electrolysis. Early estimates suggest it could be delivered at under $1 per kilogram, a fraction of the cost of hydrogen produced by renewables or reforming methane. Deeper still lies a second frontier: marine hydrogen, formed through serpentinization—where seawater reacts with ultramafic rock, forming brines and hydrogen in the process. The challenge is formidable: hydrogen diffuses quickly, reacts readily, and vanishes before detection. For now these hidden energy reserves are hard to find and even harder to extract. But if they pan out, geologic hydrogen could provide a direct replacement for natural gas (CH_4) without the carbon. In short, fusion or geologic hydrogen would not only eliminate emissions—they could drive energy costs through the floor. Cheap, clean energy at scale is the cornerstone that makes many other climate solutions exponentially easier.

Next, consider Stratospheric Aerosol Injection (SAI). This is the most controversial of climate gambits: mimicking a volcanic eruption by dispersing aerosols in the upper atmosphere to reflect a bit of sunlight and cool the Earth. It doesn't solve CO_2 buildup, but it could shave the peak off global temperatures. The idea has been around for decades in academic literature, and indeed nature proved the concept when Mount Pinatubo's 1991 eruption temporarily dropped global average temps by about 0.5°C. The attraction of SAI is its sheer leverage: a relatively small mass of particles can offset a lot of warming. Recent analyses indicate that on the order of 5 million tons of sulfate a year lofted into the stratosphere might counteract 1–2°C of warming. The cost estimates are eye-poppingly low in climate terms—on the order of single-digit billions of dollars per year to run a program deploying specialized high-altitude aircraft. In theory, for a few billion annually, SAI could buy us time by curbing temperature rise, protecting polar ice, and reducing extreme heat events. Moreover, some proponents suggest it could be tuned regionally to help stabilize weather patterns like the South Asian monsoon, potentially averting droughts or floods with huge economic implications for agriculture and water supply. Of course, it's far easier said than done. The unknown risks loom large: altering rainfall patterns, ozone depletion, political conflict over who sets the global thermostat. Early real-world experimentation has been scant. A small Harvard-backed test (SCoPEx) to inject particles from a balloon was shelved in 2021 amid public outcry and government pushback, illustrating the social license problem. Still, the fact remains—SAI *could* cool the planet quickly and relatively cheaply. It's the quintessential Axis Two idea: implausible and even unnerving, yet with a payoff so colossal that serious people cannot ignore it forever.

Now shift from sky to land and sea. Carbon-sequestering construction and mining could turn major industries from sources of CO_2 into sinks. Take cement, the literal foundation of modern civilization. Making cement currently belches out about 8% of global CO_2 emissions—roughly triple aviation emissions. But what if making building materials absorbed CO_2 instead? Several startups are working on carbon-negative cement that mineralizes captured CO_2 into the product itself. If successful at scale, every new building or road could lock away carbon rather than release it.

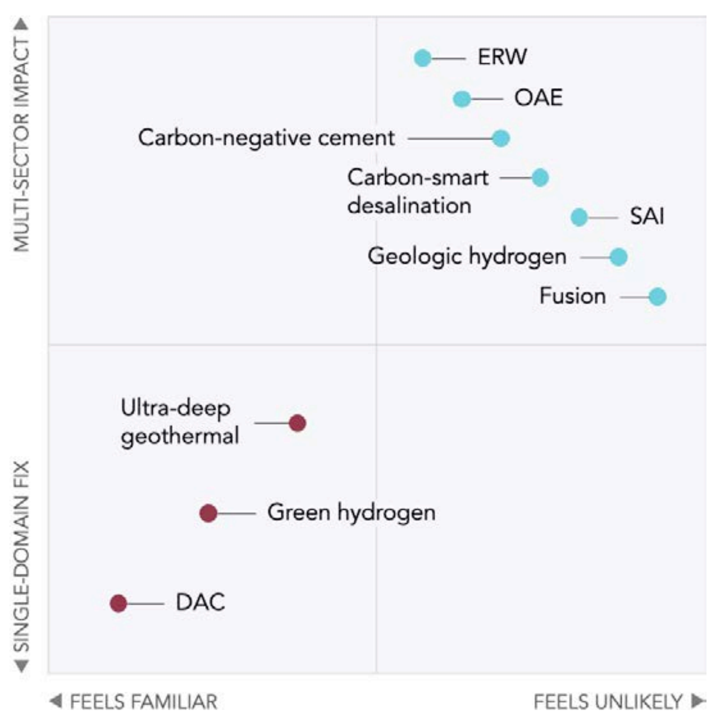
Another example: desalination plants, which provide fresh water in arid regions but at the cost of high energy use and concentrated brine waste. The world now gets over 100 billion liters of water a day from desalination, leaving behind an equally huge volume of hypersaline brine. As demand for fresh water grows (a projected 40% shortfall by 2030), desalination could expand tenfold, compounding its environmental footprint. Innovative approaches aim to combine desalination with carbon capture—using alkaline mineral feeds to both produce fresh water and convert CO_2 into stable bicarbonate in the leftover brine. In effect, ocean carbon injection: you generate clean water and permanently store carbon in the sea as harmless minerals. Such processes are in their infancy, but if proven, they tackle two crises at once (water scarcity and climate) with one infrastructure. The compounding benefits are evident: clean construction materials that store CO_2, and clean water production that neutralizes CO_2. Every ton of carbon locked into a building or into ocean rock is a ton kept out of the sky, with useful output as the co-product. It's industrial alchemy—turning pollution into profit.

Speaking of oceans, check Ocean Alkalinity Enhancement (OAE). This is essentially helping the ocean to absorb more CO_2 by adding alkaline substances (like ground olivine or lime) to seawater. The chemistry is straightforward: increasing alkalinity lets the ocean draw down CO_2 as stable bicarbonate, with the added benefit of countering ocean acidification. The remarkable thing about OAE is its scale. The oceans are vast; in principle, OAE could store tens of gigatons of CO_2 over decades by nudging the chemistry of even a small fraction of the seas. A recent consensus report by the US National Academies estimated OAE's realistic potential in the 0.1 to 1.0 Gt CO_2 per year range in the coming decades, but with further innovation it could go higher. Essentially, it could be one of the highest-leverage carbon sinks available. And it need not involve simply dumping powder into open water. One can envision designer co-benefits: building artificial islands or coastal reefs made of alkaline rock that serve as carbon-sucking breakwaters, or using alkaline materials in mariculture (say, in oyster reefs or fish farms) so that boosting CO_2 uptake also boosts biomass growth. Pilot projects are just beginning, many supported by ARPA-E and philanthropic funders, to test OAE and ensure it doesn't harm marine ecosystems. The early challenge is measurement and verification (as I'll discuss later), since tracking carbon in the ocean is hard. But if those hurdles are cleared, OAE could be a workhorse of planetary restoration—enhancing fisheries, protecting coasts, and pulling carbon, all at once. The theoretical scalability is vast: even a gigaton per year removal would be transformational, and that's within sight if engineering and public acceptance line up.

Finally, perhaps the most elegant example of a compounding climate solution: Enhanced Rock Weathering (ERW) on land.

The Smart Bet Is the Uncomfortable One

The real climate breakthroughs cluster where few are willing to bet



This involves spreading finely crushed silicate rocks (like basalt) on soils, where they react with CO_2 in rainwater and lock it into carbonate minerals over time—essentially accelerating geology. ERW has been called "carbon farming" because you can integrate it into agriculture. It turns out basalt dust not only consumes CO_2; it also fertilizes the soil. As the rock breaks down, it releases magnesium, calcium, potassium and other nutrients that many soils lack. Field trials and early deployments (by startups like Mati Carbon, Lithos, Eion, and others) have shown impressive co-benefits. Farmers see better yields—in some cases up to 40–50% higher crop yields after repeated basalt applications—because the soil pH rises (less acidic) and crops get crucial minerals. Unlike traditional agricultural lime (which is carbon-intensive to produce and emits CO_2 when it dissolves), basalt rock can achieve the same soil conditioning while removing CO_2. Every ton of basalt spread can, over its weathering, remove about 0.3 to 0.5 tons of CO_2, according to studies. Scaled globally, enhanced weathering on farmlands could feasibly sequester on the order of 2 gigatons of CO_2 per year by mid-century, while rejuvenating soils. That means potentially offsetting ~5-10% of annual emissions, all through a boost to food security. Moreover, ERW helps reduce fertilizer needs (since soils enriched with rock dust often require less synthetic input), which in turn cuts emissions from fertilizer manufacturing—a significant source of greenhouse gases (about 0.7–1.5% of global emissions.) And by improving nutrient retention in soils, ERW also curbs runoff into rivers and oceans. Fertilizer runoff today causes massive algae blooms and "dead zones" in waterways; the Gulf of Mexico's dead zone linked to Midwest farm runoff costs an estimated $82 million each year in lost seafood and tourism revenue. Healthier, carbon-rich soils leak fewer nutrients, protecting water quality and fisheries. In sum, ERW is a rare win-win-win: capturing carbon, boosting crop production, and reducing pollution. Little wonder it's attracting attention from big buyers—for instance, the Frontier climate fund (backed by Stripe, Shopify, Meta and others) has pre-purchased tons of ERW-based carbon removal to help kickstart this industry. Philanthropies and government grants are also supporting field trials on multiple continents.

All these Axis Two solutions share a key attribute: they bridge multiple industrial cycles. They don't just address climate in a vacuum; they tie into energy, water, agriculture, or construction, delivering compounded benefits. Fusion links energy and economic productivity. SAI ties climate stability to water and agriculture. Carbon-negative cement marries construction and emissions storage. OAE blends ocean health with atmospheric CO_2 removal. ERW connects farming with carbon management. Solving two or more problems at once means the whole can be much greater than the sum of parts—the exponential impact VCs claim to seek, finally made real.

Yet for all their promise, these frontier solutions face a common chokepoint. From fusion experiments to fields dusted with rock, from alkaline-enhanced waves to aerosols in the stratosphere, they all confront the same hurdle on the path from lab to industrial scale: knowing what the hell is going on, in real time. In short, they need the ability to *measure* and *verify* their processes in practice—cheaply, quickly, and accurately. Each of these techniques is pushing into unfamiliar territory. Success will depend on continuous learning and adjustment in the field. You can't manage (or finance) what you can't measure, especially when asking society to trust something as bold as geoengineering or novel farming methods. Thus, the missing ingredient for Axis Two innovations is an omnipresent sensing and analytics capability—eyes on the ground (or in the air, or sea) that can provide instant feedback and proof of results. Build that enabling layer, and the door opens for these nascent industries to scale safely and investably. Lacking it, they remain stuck in trial mode, unable to convince stakeholders or optimize processes.

FROM THEORY TO REALITY – MEASURING EVERYTHING, EVERYWHERE

Here enters what I call the *Impossible Sensing* factor. The next frontier in climate tech is not a new material or a new reactor—it's the deployment of ubiquitous, real-time measurement to turn promising science into bankable infrastructure. All the groundbreaking solutions I reviewed share a dependency on data: How much CO_2 is actually being captured, and where? Are we improving or degrading the environment locally as we intervene globally? Can we verify outcomes to unlock financing and market incentives (carbon credits, for instance)? Getting these answers used to require long waits and expensive lab tests—a fatal bottleneck. But the real limitations go deeper: traditional lab-based models simply don't scale. They can't support the granularity, speed, or ubiquity these climate solutions demand. And above all, there's the sobering fact: task every lab with measuring what matters, and the system buckles instantly—overwhelmed not by complexity, but by sheer volume. But just as the challenge reaches a peak, technology is offering a way through.

At Impossible Sensing—a company born from this very recognition—we decided to tackle the measurement problem head-on. Our founding insight was that advanced sensing technologies already exist (NASA uses them on Mars, for example), but on Earth they hadn't been applied to climate and industrial problems in the right way. Why? Because nobody asked customers what they actually needed. For years, sensor development was led by brilliant technologists building ever-more-sophisticated instruments that often sat in labs or required expert operators. Meanwhile, industries from mining to agriculture muddled through with sparse, slow data. The result: crucial decisions were made in the dark or with months-long delays.

We took a contrarian approach: go to the hardest environments, and put the lab in the field. If breakthroughs hide in overlooked places, we would look there. We weren't afraid to pursue solutions that seem irrational at first—or, as Arthur C. Clarke put it, venturing a little way past the limits of the possible. And it works: we delivered results that used to be science fiction. Sensors that operate in situ: in the middle of a cornfield, on the ocean floor, down a borehole, or 20 kilometers up in the sky. And not just operate, but deliver laboratory-grade analysis instantaneously. Laser-Induced Breakdown Spectroscopy (LIBS) is just one example: a technology that began as a tool for Mars rovers and now enables carbon accounting in fields and factories. It reflects the broader arc of our work—redeploying space-proven instruments to tackle Earth's most urgent challenges. In essence, LIBS uses a laser pulse to vaporize a tiny bit of a material and reads the elemental composition from the emitted light. On Mars, the Curiosity rover's ChemCam uses LIBS to analyze rocks from a distance, saving the rover from driving to each target. We realized this could be a game-changer on Earth. With modern electronics and AI, a rugged LIBS device can identify elements from hydrogen to uranium in seconds, on-site, with no need to send samples to labs. Think of what that enables. It collapses the decision cycle from weeks to minutes. Costs are falling and integration with AI is accelerating, following the classic path of a once-esoteric tool becoming ubiquitous.

For the climate solutions on Axis Two, such sensing is absolutely pivotal. It provides the feedback loop to iterate and prove efficacy, turning speculation into verification. Let's illustrate how an embedded measurement layer changes the game, case by case.

Precision carbon farming (ERW)

Instead of taking a handful of soil samples from a 100-acre field and waiting two months for a lab to tell how much carbon was stored, imagine scanning the entire field in a day. This is now feasible. A tractor-towed sensor can shoot lasers into the soil as it moves, reading carbon concentrations every few meters. In one pass, you collect what would have taken hundreds of manual samples. The data is instant and granular, showing exactly how much CO_2 the crushed rock is sequestering and how soil health is changing. Farmers get a map of their fields' nutrient status—they might see that basalt application raised magnesium and pH in one area (boosting yields), but perhaps less so in another area that needs more. They can adjust accordingly. Crucially, the carbon removal can be verified and credited. What used to be an academic notion ("some of the CO_2 eventually becomes carbonate in soil") becomes a certifiable outcome with numbers attached (tons of CO_2 per hectare). This unlocks carbon credit revenue for farmers and gives buyers confidence. Lithos, for example, has been deploying such approaches, allowing them to sell permanent carbon credits to pioneering buyers like Frontier and Microsoft. The old way would require trust and uncertainty; the new way provides an audited carbon inventory in the ground. All at a cost dramatically lower than traditional lab testing (I'm talking sensor costs that are a fraction of the cost per sample of sending to labs, which can be \$100–\$200 each. In sum, real-time, in-field measurement turns ERW from a hopeful concept into a bankable agricultural practice with revenue streams for farmers and verified climate impact.

Ocean carbon monitoring (OAE and ocean sinking)

Historically, measuring carbon in the ocean meant dispatching research ships, dropping sensors or bottles, and performing meticulous chemistry back on shore. A single comprehensive ocean carbon survey can run into the tens of millions of dollars and take years. That doesn't fly if we want to validate a fast-moving OAE project. Enter autonomous platforms. We have equipped unmanned surface vehicles and even robotic submarines with laser-based sensors that detect dissolved inorganic carbon and alkalinity changes in seawater in situ. The sensors read out carbon chemistry continuously as the drone moves. No ships, no months of waiting. Data can beam back via satellite each day. A demonstration project recently showed that an autonomous float could track the uptake of carbon in a test patch of alkalinized water within weeks, something that previously might have required laborious sample collection and lab work. By cutting the time and cost by orders of magnitude, such systems save huge amounts per project. One could easily be looking at savings of \$10–\$20 million in monitoring expenses for a given large-scale OAE trial, compared to classical methods. And they provide something even more valuable: the ability to course-correct. If sensors show the alkalinity is dispersing too fast or marine pH is swinging beyond safe ranges, operators can adjust the material addition in near real-time. Again, we move from theory to practice safely. The ocean is a tricky place—but eyes in the water make it a knowable, steerable one.

Carbon-negative industry (cement and desalination)

In processes like CO_2-curing of cement or mineralizing CO_2 in desal brine, controlling the chemistry moment-to-moment is key to maximizing carbon uptake. Traditional process control might rely on infrequent sampling or indirect proxies. With new sensors, we can directly monitor the concentrations of carbonates or key ions in the mix as the process runs. For instance, a laser sensor installed in a cement curing chamber can detect how much CO_2 has been absorbed into the curing blocks by analyzing their surface chemistry, enabling precise control of curing times and CO_2 dosages. In a desalination plant, a real-time sensor could analyze the brine effluent for remaining alkalinity or precipitated minerals to ensure CO_2 injected is fully reacted and safely stored. These measurements, if done by external labs, would be so slow and expensive that operators wouldn't bother except in post-hoc fashion. But with in-line monitoring, the process becomes feedback-driven. One large carbon-to-mineral project reported that advanced sensors reduced their monitoring costs by an order of magnitude (to roughly one-tenth of previous costs) while turning what was a weekly lab report into an instantaneous control signal. Essentially, you spend a penny to save a dollar, and make the whole system more efficient to boot. Proactive control means you catch issues (like a dip in CO_2 uptake rate) immediately, rather than discovering after a month that a batch underperformed. This is the difference between something that might work on paper and something that can operate as a reliable industrial system.

Stratospheric observation (SAI)

How do you monitor a haze of particles you released 20 kilometers up in the atmosphere? This has been a thorny challenge. You can't exactly build a lab up there; traditionally you'd send occasional instrumented aircraft through the aerosol plume or use satellites that infer particle properties from afar. But satellites often lack the resolution to distinguish a small test injection, and airplanes are costly and infrequent. The new approach is to use high-altitude drones or balloons carrying miniaturized versions of lab instruments. Impossible Sensing has been involved in developing ultra-light sensors that can float into the lower stratosphere and directly measure aerosol composition and reaction byproducts in real time. In principle, one could deploy a fleet of solar-powered high-altitude drones that continuously surveil the injected aerosol cloud—tracking its size, dispersion, and chemical interactions (for example, formation of sulfuric acid, nitrates, etc.). This would give an unprecedented picture of both the positive effects (how much sunlight is reflected, how much cooling results) and negative side-effects (does it affect ozone or cirrus clouds?). Early experiments with small airborne payloads have shown we can successfully detect the chemical fingerprint of injected particles without needing to recover the instruments. This means scaling up SAI research becomes far more tenable: you're not going in blind, and you're not waiting on an arduous sample-return mission to tell you if you made things better or worse. Continuous, in-situ data from the stratosphere would turn SAI from a risky moonshot into a rigorously monitored climate tool, should the global community choose to use it. Monitoring overhead would be a tiny fraction of the deployment cost—like fitting "eyes" on a thermostat in the sky, to ensure we don't overshoot or misfire. It's the kind of safeguard that would be absolutely required for SAI to ever move forward, and now it's within reach.

In each of these cases, sensing turns theoretical potential into actionable, tradable outcomes. Carbon credits for soil carbon, verified by spectral data across a farm, can be sold with confidence (and free up banks to lend against future credits). An OAE project can secure insurance or government approval because it can demonstrate environmental safety in real time. A desalination plant can earn incentives for carbon sequestration because it has continuous records of net CO_2 mineralized. A fusion reactor startup can attract major financing because sensors prove it hit performance targets rather than just relying on simulation. In short, measurement translates to trust—trust that unlocks capital, policy support, and public acceptance.

It's no coincidence that Impossible Sensing's technology originated in space exploration, where remote, real-time analysis is the only option. On the Moon or an asteroid, if you want to know what resources are there—say water ice or metal ores—you send a rover or lander with LIBS or similar instruments. In fact, our team's heritage includes mapping lunar and asteroid resources as part of prospecting missions aimed at the trillion-dollar space mining frontier. We're literally helping identify lunar ice that could become rocket fuel and helium-3 that might power fusion reactors.

Those are tomorrow's industries. But the point is, that same technological edge is exactly what's needed in today's climate fight. I often joke that we're bringing space-age tools down to Earth—without the price tag. It's extremely gratifying to see a technique that's seeking life on Mars now verifying carbon removal in a Kansas corn field, or a sensor concept for asteroid prospecting being used to optimize a geothermal well. We live in wild times.

CONCLUSION – INEVITABLE CONVERGENCE

Let's step back and revisit our model of civilization: invest, produce, consume. For 200 years, that trilogy came with an unwritten fourth act—pollute. It was an accepted trade-off of progress, externalized and invisible. We're at the end of that bargain. The logic of industry is being rewired to internalize carbon and environmental costs, not as a moral aspiration but as a physical and economic necessity. In other words, invest, produce, consume is evolving to invest, produce, consume, *restore*. And there is money to be made in restoration, in closing loops that have long been left open.

The strategic narrative emerging—and hopefully made clear in this report—is that the most promising climate solutions will be those that embed themselves into the fabric of industry, rather than stand apart as a pure expense. The sweet spot is where fighting climate change generates compounding returns across multiple sectors. That is the new industrial logic: profit and planet aren't at odds if technology aligns their incentives. We saw how enhanced weathering makes farms more productive, how carbon-built concrete could meet infrastructure needs, how abundant clean energy unlocks growth, how cooling the planet might safeguard water and food supplies. These intersections create self-reinforcing cycles. An investment in one yields dividends in another.

Of course, to bring these solutions to maturity, we must navigate the risks and failures along the way. Not every moonshot will land. But the trajectory is set. Even the more incremental Axis One approaches, for all their pitfalls, have served a purpose: they lit the path and built urgency. Now the baton passes to the harder, bolder endeavors that can actually bend the curve. Policymakers and investors are increasingly savvy to hype—they demand proof. It's about time. It means the truly transformative ideas, backed by data, will rise to the top.

We find ourselves at a remarkable inflection point. The world is awash in capital seeking climate-positive investments, from green bonds to venture funds. Governments are marshaling industrial-policy levels of support (the US IRA, EU Green Deal, etc.), creating markets for solutions that work. Public opinion, especially among the young, has shifted from "somebody should do something" to "we will build the future we want." In boardrooms and UN forums alike, the message is clear: the time for half-measures is over.

History shows that societies remake themselves when necessity and opportunity meet. We are at that juncture. The necessity is obvious—a livable climate. The opportunity is to usher in a new wave of innovation that not only averts disaster but makes civilization more resilient and prosperous. It's entirely plausible that by 2050 we look back and see that decarbonization was not a cost burden but the greatest economic driver of the 21st century—that growth was compatible with ecological balance by design.

I like to imagine a future where our three core actions—investing, producing, consuming—all reinforce a stable climate. Invest in industries that inherently remove carbon or regenerate ecosystems, and earn returns from the value created (be it energy, materials, or services). Produce goods in ways that embed sustainability (every factory a carbon capture hub, every farm a carbon sink, every new construction a net-negative emitter). Consume in a circular economy where waste is feedstock and ownership gives way to stewardship (using things without depleting things). This is not utopian fluff; it's a realistic extrapolation of trends already underway. A coal plant already makes no economic sense in most places—soon, a polluting plant of any kind will make no sense when cleaner alternatives are cheaper and better. Industries will compete on who can be cleaner and more efficient, much as they once competed on who could be bigger and faster.

In the coming decades, we will likely see fusion power lighting grids, gigaton-scale CO_2 removal credits trading on markets, crops grown with basalt dust feeding billions, and perhaps even silver stratospheric linings damping the worst heat spikes (if we're wise). And threading through it all will be the digital nervous system of constant measurement, ensuring accountability and trust. If this sounds optimistic, it's because optimism has become pragmatic. We no longer have the luxury of pessimism; there is too much to do, and remarkably, we have the tools to do it.

The industrial revolution set us on the path of fucking the climate. The next industrial transformation—a climate revolution—is about fixing what we broke while taking civilization to new heights. It's about inevitability, not hype. The inevitability that human ingenuity, when guided by clear incentives and good data, will solve even the toughest problems. The logic that built our modern world can evolve to save it. In fact, it's already happening.

In the final analysis, this is not merely about technologies or policies—it's about who we are as a species at this point in time. Are we the creatures of habit that go off the cliff clinging to old ways? Or are we the problem-solvers who venture a little beyond the known, confident that we can course-correct as needed? The evidence of history and the trends of today suggest the latter. We break problems into bits, we iterate, we learn, and then suddenly, we leap.

The climate challenge is immense, yes. But mapped onto these two axes—incremental and exponential, short-term and long-term, surface and fundamental—we can see a path through. We will deploy what's ready now, double down on what offers multiple benefits, and relentlessly measure our progress. That approach all but guarantees that we will surprise ourselves with what is possible by 2030, 2040, 2050.

A climate-aligned civilization is not some distant dream. It is under construction, in labs and startups and pilot projects around the globe. The new industrial logic demands it, and economic gravity is starting to favor it. Investing, producing, and consuming will never be the same—and that's a good thing. The arc of progress, bent wisely, can indeed bring us to a cooler, cleaner, and more abundant world. It's ours to make it inevitable.

ABOUT THE AUTHOR

After retiring from international basketball in 2005, Pablo got his PhD in physics in 2008 and worked through an alphabet of space organizations, NASA, CSA, and SETI among others.

His work in planetary science has won many awards, including NASA GAAs, the highest level of peer-nominated awards given to NASA teams.

In 2016 Pablo set up Impossible Sensing to crack impossible problems in space and industry. His approach: look where others don't. The breakthroughs followed.

Success bred success: technology firsts in energy, ocean, and agriculture led to three more startups—all speeding the green transition. Bold innovations followed. More industry awards, too.

Today Pablo leads a team turning space-proven sensing into climate tech, delivering in weeks what takes others years.

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