Still Thought Leadership

Green hockey sticks

Are key climate technologies breaking through?

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Executive Summary

Deep, rapid, and viable decarbonization is possible only through climate technologies gradually outcompeting and replacing carbon-intensive incumbents. Successes exist—renewables already do this, and electric vehicles are following suit—but most remain commercially uncompetitive. Climate techs that are close to commercial maturity may offer high climate and commercial bang-for-the-buck.

The world is familiar with the theory of change. As solutions scale, typically their quality improves and costs drop, driving a self-reinforcing process of deployment. Eventually, a new technology improves enough to outcompete an incumbent, initiating a transition from old to new. The climate transition is no different; climate techs that facilitate greenhouse gas (GHG) emissions reductions, from wind turbines to rudimentary interventions that support nature's proper functioning, need to scale by becoming 'better' than incumbent solutions across all dimensions of performance. The sticking point is that most remain economically uncompetitive today[1], and as a result, the pace and scale of deployment in almost every sector is too modest to limit global heating to well below 2°C. Still, grounds for optimism exist.

Diamonds in the rough

Pockets of progress show climate tech deployment may not repeat earlier sluggish trends. Solar and wind's unexpectedly fast deployment led to almost exponentially improving costs, repeatedly proving wrong the pessimistic predictions of mainstream climate models. In 2023, renewables accounted for 87% of all new power capacity, globally. The same is happening with electric vehicles, batteries, electrolyzers, heat pumps, and more, and such forces will only strengthen as climate change hits humanity harder.

Engineer tipping points

Expediting a tech's journey from the lab to the market requires targeted strategies. Some are already underway; new "small tent" climate strategies, characterized by like-minded stakeholders focusing resources on specific techs, seek to fill the implementation gap left by the Paris Agreement by moving key climate technologies closer to commercial tipping points.

These processes require significant investment, creating a key role for financial markets. There is enough capital today to fund the transition, but its distribution means not all climate techs attract the funding they need. Risky, immature climate techs have little trouble finding investment from risk-tolerant venture capital. The same applies to established, mature climate techs that appeal to low-risk but deep-pocketed institutional investors. Those in the middle face a gap, and financial innovation will prove key to ensuring capital avoids becoming a bottleneck on deployment in the same way infrastructure is today. Equally

[1] Climate techs include any solution that reduces, removes, or avoids greenhouse gas emissions; this report focuses on 15 key climate technologies, and a full list is available in the companion 'climate tech passports' publication.

important are a new breed of active impact investors and philanthropists, who use their expertise to help climate techs successfully ‘cross the middle’.

Tracking the ceiling of possible breakthroughs

Anticipating where tipping points lie is important. Policymakers need sight of these trends to inform tax, subsidy, and regulatory options. Financial markets need sight of probable risks and rewards. Large companies need visibility on climate tech’s commercial viability to plan transition goals. In this vein, we applied a 3-part framework to 15 key climate technologies, establishing: w*hat* each tech’s impact and commercial opportunities are; *how* they are developing and scaling; and *why* they may, or may not, present near-term climate and commercial opportunities.

If all 15 were fully deployed, they could reduce, avoid, or remove around 200 gigatons of GHG emissions—enough to meet around 70% of the 1.5°C carbon budget.[2] Alone they are not sufficient, but together they offer powerful levers to deliver most of the decarbonization needed over the next decade. We draw three conclusions.

1. Tipping points are approaching for some sectors. For others, they lie beyond 2035.

Several climate techs are near or have passed tipping points where they may become cheaper and better than old tech, such as solar, wind, and batteries. Others may pass tipping points before 2030, including battery-powered electric vehicles and heat pumps. Some may not reach tipping points in the next decade, such as synthetic fuels that look to remain stubbornly expensive in the near-term.

2. Climate technologies require significant investment, but some offer greater abatement.

Reaching 2035 deployment targets will cost trillions of dollars, mostly driven by mature climate techs. Achieving Net Zero requires these solutions to deploy quickly, raising near-term implementation costs. Despite the cost, climate techs that need to further scale in the short term—wind, solar, batteries, EVs, and more—offer the greatest opportunities for reducing emissions.

3. Impactful technologies are those close to tipping points with high abatement potential.

Focusing reform, resources, and capital on bringing forward tipping points for almost-mature, high-abatement climate techs is possibly the most efficient way to quickly reduce emissions in the near term. EVs, for example, are a relatively mature technology where price parity with conventional cars is near, and each additional EV generates clear, significant, and reliable greenhouse gas savings.

Find more insights in our companion pieces:

www.ubs.com/insittute

[2] According to the Global Carbon Project (2024), the remaining carbon budget for a 50% likelihood of limiting global heating to 1.5°C is 275 gigatons of carbon dioxide from the beginning of 2024.

1. Engineer tipping points

At a glance

- Climate goals require mass-scale deployment of climate techs, but most remain commercially uncompetitive.
- The tide could be turning, as evidenced by recent success in the power and transport sectors. The same needs to happen in every sector, for as many climate techs as possible, to achieve Net Zero.
- As technologies scale, typically their quality improves and costs drop, driving self-reinforcing deployment and improvement. Financial markets enable this capital-hungry process.

Many countries have set Net Zero targets for 2050, which today cover around 90% of global gross domestic product and greenhouse gas (GHG) emissions.[3] Each implies a mass-scale deployment of climate technologies that can facilitate economy-wide emission reductions. The key issue is that most climate techs, despite offering multiple benefits, are too immature to easily scale (Box 1), owing to technological barriers, high costs, supply-side bottlenecks, too little demand, and insufficient policy support. In almost every sector, the pace and scale of climate tech deployment remains too low to keep warming below 2°C.[4]

Box 1: Commercial maturity is the key yardstick to judge climate techs

One way to gauge the journey of any technology from the lab to the market is the idea of commercial maturity. There are two parts: whether solutions are technically developed enough to deploy widely, and—crucially—whether they are economically competitive with incumbents. For instance, plant-based alternative proteins are technically-mature today, but they remain uncompetitive with animal-derived protein on cost and non-cost features like texture, smell, and taste.[5] This means consumers are less likely to buy them, capping the speed at which they avoid GHG emissions by displacing carbon-intensive, animal-derived protein. The concept provides an important yardstick for whether climate techs can organically scale rather than relying only on 'supply push' policies like subsidies. The longer climate techs remain commercially immature, the slower the transition will be—and the lower its economic benefits.

[3] Net Zero Tracker (2024), *Data explorer*.

[4] Bohem, S. et al (2023), *State of Climate Action 2023,* Systems Change Lab.

[5] See survey evidence, such as The Good Food Institute (2023), *State of the Industry Report: Plant-based: Meat, seafood, eggs, and dairy*.

Diamonds in the rough

There are concrete grounds for optimism. Pockets of progress show climate tech deployment may not linearly repeat the sluggish trends we see in the rearview mirror. This trend is obvious in the power sector, where in the last five years, renewables provided 26% of global electricity, but accounted for 87% of new capacity additions.[6] It is also visible in the car market, where EVs are just 3% of cars on the road, but 18% of new sales.[7]

Decarbonization is clearly underway, and it may happen faster than the mainstream expects. Past energy shifts occurred through 'better' solutions replacing 'worse', typically over 50 years.[8] However, unlike historical examples, the world is actively pushing for climate techs to scale, providing strong prevailing winds to established trends of exponential improvement. For instance, while renewable prices fall on average 10% every year, fossil fuel prices haven't budged for 140 years.[9] Other climate techs are following suit, such as EVs, batteries, electrolyzers, and heat pumps. The process of electrifying almost everything will only accelerate as climate change hits humanity harder and harder.

The theory of change

On their journey from the lab to widespread adoption, technologies tend to follow a standard path (Figure 1). Early adopters support pilot projects, and as the new technology improves, a tipping point may arise where it begins to outcompete incumbents, entering the mainstream arena. Initial takeoff may be slow but tends to accelerate, generating a classic adoption "S-curve."[12] The transition speed is driven by "reinforcing" and "balancing" feedback loops. Reinforcing loops, such as preferential regulations or tax incentives, support early growth in the new technology's market share (Box 2), while balancing loops resist change, shoring up incumbents. Exponential growth only occurs once the former overpowers the latter.

Box 2: Reinforcing feedback loops

- **Learning by doing:** Deployment leads to innovation as the product and its production process are optimized, reducing costs and encouraging further deployment (Wright's Law). For instance, photovoltaics' costs fell roughly 38% for every doubling of capacity since 2010.[10]
- **Economies of scale:** As production scales, fixed costs spread across greater volumes, leading to lower unit costs, and a higher rate of output. Take batteries, which become about 19% cheaper with every doubling of output.[11]
- **Network and coordination effects:** The more a solution is used, the more its supporting infrastructure gets developed, increasing the value proposition for late adopters. For instance, the more EV charging points are installed, the more convenient EVs become.
- **Social norms:** As new solutions deploy, their visibility among non-adopters increases (Rogers's Law). Alternative proteins benefit from positive word-of-mouth, given they compete with meat on fuzzy features like taste and texture.

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[6] Includes solar, wind, bioenergy, hydro; Ember (2024), *Global electricity review 2024;* IRENA (2024), *Renewable capacity statistics 2024.*

[7] Statistics include Battery Electric Vehicles and Plug-in Hybrid Electric Vehicles; IEA (2024), *Global EV Outlook 2024.*

[8] Fouquet, R. (2016), *Historical energy transitions: speed, prices, and system transformation*, Energy Research & Social Science.

[9] Except cyclically and due to stochastic events, such as the 2005 US shale gas revolution.

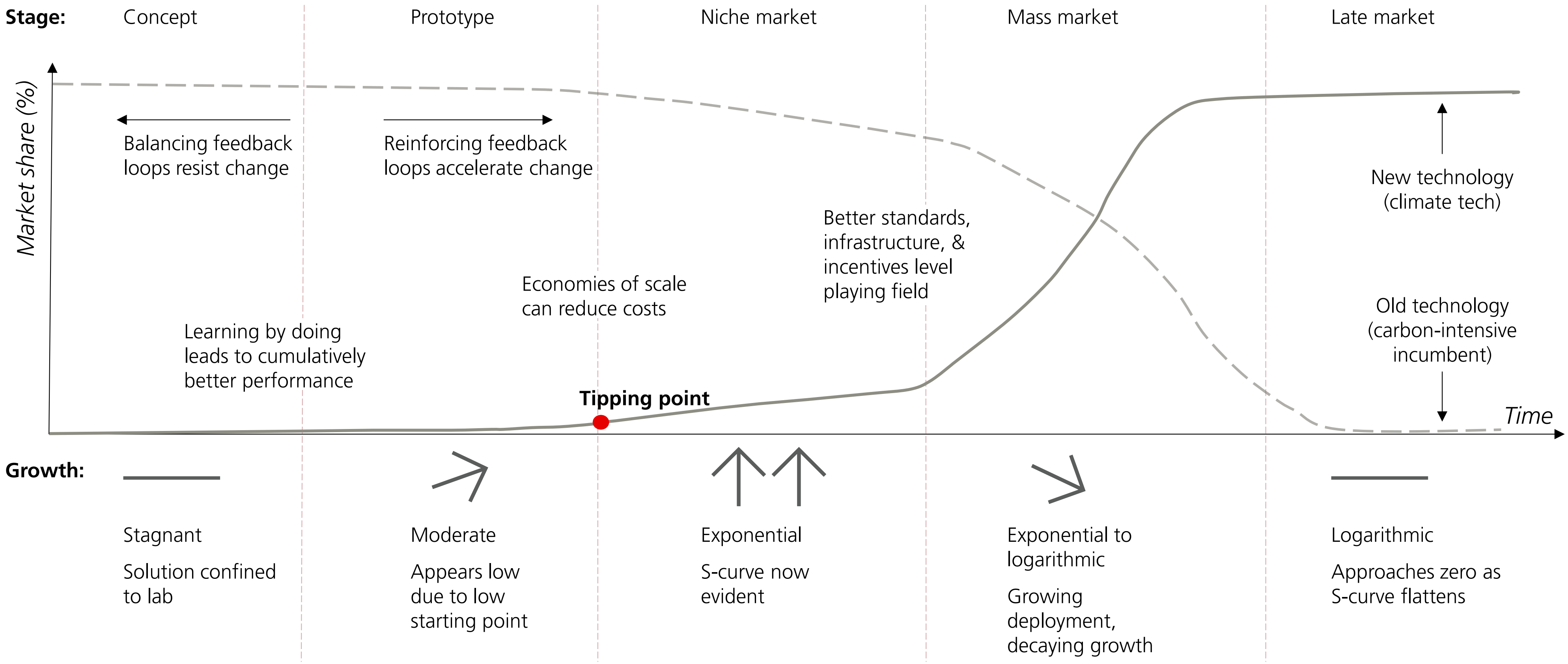
[10] UBS calculation; Average cost reduction for every doubling in installed capacity, 2010 to 2022, Levelized Cost of Energy from IRENA.

[11] Average cost decline for lithium-Ion batteries, 1991 to 2022; Waalter, D. et al., (2023), *X-Change: Batteries,* Rocky Mountain Institute, P6.

[12] Rogers, E., (2003), *Diffusion of innovations,* NY: Free Press; The original was published in 1962.

Figure 1: Breakthrough technologies follow S-curves

Past the tipping point, the transition from old to new tech is likely irreversible



Note: This version was made by the authors following a review of existing versions.
Source: EEIST (2024); RMI (2022); IPCC (2022); Victor, D., Geels, F., and Sharpe, S. (2019); IEA et al. (2023); Lenton, T. et al. (2023); UBS

Past this tipping point, the transition from old to new tech is likely irreversible, creating momentum that can stay the course despite short-term volatility, such as supply bottlenecks or lack of supporting infrastructure. Using this lens, we evaluate 15 key climate technologies that either: reduce emissions by improving efficiency, such as alternative proteins; substitute carbon-intensive energy sources with more sustainable and renewable ones, such as wind and solar power; or neutralize emissions by removing them from the atmosphere, such as nature-based solutions and carbon capture and storage.[13]

Climate techs will follow different S-curves

Past examples suggest the nature of the tech itself is important for sorting short, tall S-curves from longer, protracted ones (Figure 2). Small, relatively simple technologies often have a standardized nature, enabling learnings to pass easily from one generation to the next. Several fast-growing climate techs in the power sector reflect this phenomenon—first solar and wind, and now batteries and electrolyzers. Large and more complex climate techs face a tougher road to scaling. Nuclear power plants need to be designed for specific sites and to comply with varying regulatory regimes, making each project unique and rendering any learnings less universally applicable. As a result, costs barely fall as deployment increases. In nuclear's case, costs even rose over time as regulatory regimes set a rising safety benchmark.

Figure 2: Exponential cost reductions are less likely for complex, bespoke technologies

Small, relatively simple technologies often have a standardized nature, and learnings pass easily from one generation to the next. Large and more complex climate techs face a tougher road to scaling

Design complexity

Standardized	Mass-customized	Customized	
Standardized complex climate tech systems e.g., Direct reduced iron electric arc furnace green steel plants	Platform-based complex climate tech systems e.g., Small module reactor nuclear plants, CCS	Complex climate tech systems e.g., Nuclear power plans, bioenergy with CCS	Complex
Mass-produced complex climate tech e.g., Electric vehicles	Platform-based complex climate tech e.g., Wind turbines, concentrating solar power	Complex-customized climate tech e.g., biomass power plants, geothermal power	Design-intensive
Mass-produced climate tech e.g., Solar PV modules, Light-Emitting Diodes	Mass-customized climate tech e.g., Rooftop solar PV	Small-batch climate tech e.g., Building envelope retrofits	Simple

Need for customization

Source: Adapted from Malhotra and Schmidt (2020); UBS

Each climate tech needs an alignment of several complementary factors to bring forward tipping points. A case in point are calls for a universal carbon tax: By making carbon-intensive technology more expensive, small changes in cost can bring forward tipping points for technologies where price is key. One example is cars, where the price delta between EVs and internal combustion engine (ICE) vehicles is small—and so easily closed by a reasonable carbon tax—and sticker prices drive purchasing decisions. However, the market context matters. The

[13] For the full set of climate techs covered in this report, see the accompanying climate tech passport publication.

price difference between conventional jet fuel and synthetic alternatives is so large that a universal carbon tax, if set high enough to close the gap, would be politically unfeasible.

Price is also not the only elephant in the room. Cars did not replace horses because society taxed horses beyond anyone's budget. Instead, many complementary factors aligned and strengthened reinforcing feedback mechanisms over time: Fossil fuel supplies became cheap and reliable; roads and other infrastructure got built; and Henry Ford-style manufacturing took off—all benefitting cars over horses.[14] Fortunately, the global community is moving from generalist approaches to climate policy toward specific prescriptions, creating an opportunity to engineer technology-level tipping points.

From big to small tent

Approaches to climate change were initially "big tent." They sought universal participation—a global solution for a global problem. The most well-known example is the Paris Agreement—the outcome of the 2015 Conference of the Parties (COP). Rather than mandating GHG emission reduction targets, the Paris Agreement asked countries to volunteer individual targets to increase participation. Today signatories account for 99% GHG emissions.[15]

However, few concrete plans for decarbonization emerged from the Paris Agreement. Current national targets contain only enough action to limit warming to around 2.5°C, well above the main 1.5°C target. [16] Mostly static, these targets do not reflect rapidly improving climate tech, which would increase feasibility of a faster and cheaper transition. Updated to include recent improvements, current national climate targets could close the emissions gap to the 1.5°C target by a third.[17] The big tent approach is useful for encouraging participation, but not necessarily for promoting rapid climate tech deployment. In response, a "small tent" approach has recently emerged. Smaller groups of like-minded stakeholders focus their expertise, capital, demand, and other resources on specific sectors or climate techs, charting clear plans for others to align behind (Box 3). They fill an important implementation vacuum created by the Paris Agreement, and by crafting the conditions to trigger tipping points, they increase the likelihood of climate techs climbing S-curves.

Capital markets in the small tent

Each climate tech transition will be a capital-hungry process, creating a key role for financial markets rather than relying solely on government or corporate balance sheets. Estimating a price tag for limiting global heating to below 1.5°C is extremely complicated, and estimates vary,[18] but the investment will be worth it given that the downside of runaway climate change is, in theory, limitless.[19] A recent estimate suggests a rapid transition to renewables by 2050 would generate financial gains through net present savings of USD 12tn, largely due to renewables' increasingly economical costs and high efficiencies.[20]

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[14] Sharpe, S., (2023*), Five times faster: Rethinking the science, economics, and diplomacy of climate change*.

[15] European Parliament, (2016), *The Paris climate change agreement*.

[16] Average likely temperature alignment of the 2030 NDC targets if fully implemented, from estimates including the United Nations Environment Program, Climate Action Tracker, and Climate Resources; for the analysis, see Energy Transitions Commission, (2024), *Credible contributions: Bolder plans for higher climate ambition in the next round of NDCs*.

[17] Target here refer to Nationally Determined Contributions; see ETC, (2024), *Credible contributions: Bolder plans for higher climate ambition in the next round of NDCs*.

[18] Cumulative investment need between 2020 and 2050 range from USD 109tn to USD 250tn, as per Dai, L. et al., (2023), *Green equity exposure in a 1.5°C world: Applying climate investment trajectories with green revenue*, LSEG.

[19] Weitzman, M., (2011), *Fat-tailed uncertainty in the economics of catastrophic climate change*, Association of Environmental and Resource Economists.

[20] War, R. et al., (2024), *Empirically grounded technology forecasts and the energy transition,* Joule.

Box 3: Countries, companies, and investors are spearheading "small tent" approaches

- **Countries:** A prominent example is the 2022 Breakthrough Agenda. Its members represent about 50% of global GDP—enough to drive global deployment of climate tech if all members pull in the same direction. Among other things, members are asked to implement phase-in dates for zero emission vehicles by 2040 at the latest, after which gasoline vehicles cannot be sold. Such national commitments cover only 12% of the global market today, but this figure rises each time a new member signs up. If all members implemented a target, it would cover most of the global market, sending an increasingly strong signal to industry and consumers that zero-emission vehicles will eventually dominate.[21]
- **Corporates:** Large corporates increasingly use Advanced Market Commitments (AMCs) to support immature climate techs. Originally used by governments to encourage vaccine development, AMCs promise to buy or subsidize a product when it is fully developed, or when it reaches a pre-agreed price level. This reduces perceived business risks, helping innovators access a wider pool of capital to fund product development. In the climate tech space, corporates increasingly use AMCs to give innovators an incentive to invent and scale new products. Recent examples include AMCs between H2 Green Steel (now called Stegra) and car makers; Syre, a low-carbon textile producer, and clothes companies; and Climeworks, a carbon removal company, and multiple large corporates.[22]
- **Investors:** Technologies draw on different financing sources as they scale: equity and grants in the early years, and project finance and debt as they commercialize. This classic journey may not hold for climate tech. Many, such as carbon removals, have small and uncertain markets today, making it difficult to access capital. Addressing this gap, an investor-led initiative, which includes UBS, recently defined the financing needs of seven climate tech archetypes, detailing how much capital each may want to raise, at what stage, and from what sources.[23] This reduces uncertainty for innovators while building important networks of investors and expertise.

By all counts there is not enough capital flowing toward the transition. Scenarios on average suggest climate finance needs to rise from USD 1.3tn in 2021 to USD 8.3tn by 2030.[24] Yet, to their disadvantage, most mainstream discussions on this topic stop at this point, framing the job of financial markets as one of "more capital needed." This is overly simplistic, because financing decarbonization is more complicated than simply throwing money at climate tech. Indeed, attracting too much investment too quickly can inflate speculative asset bubbles which, upon bursting, can change the shape and pace of any subsequent tech transition.[25]

It can be argued that there is enough capital in the world to fund decarbonization—the global asset management industry had almost USD 120tn of assets under management as of 2023.[26] The real problem is its distribution across climate techs, which is shaped by the nature of the industry. A helpful way to frame this mismatch is through decarbonization's "missing middle" (Figure 3).

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[21] International Energy Agency et al., (2024), *The Breakthrough Agenda Report 2023*.

[22] H2 Green Steel, (2024), *H2 Green Steel raises more than €4 billion in debt financing for the world's first large-scale green steel plant;* Syre, (2024), *Syre raises $100 million Series A funding – Shortlists Vietnam and Iberia for first gigascale plants;* UBS, (2022), *UBS collaborates with Neustar and Climeworks for removing CO_2 from the atmosphere.*

[23] The Climate Brick, (2024), *The missing manual for scaling climate tech: 2024 edition.*

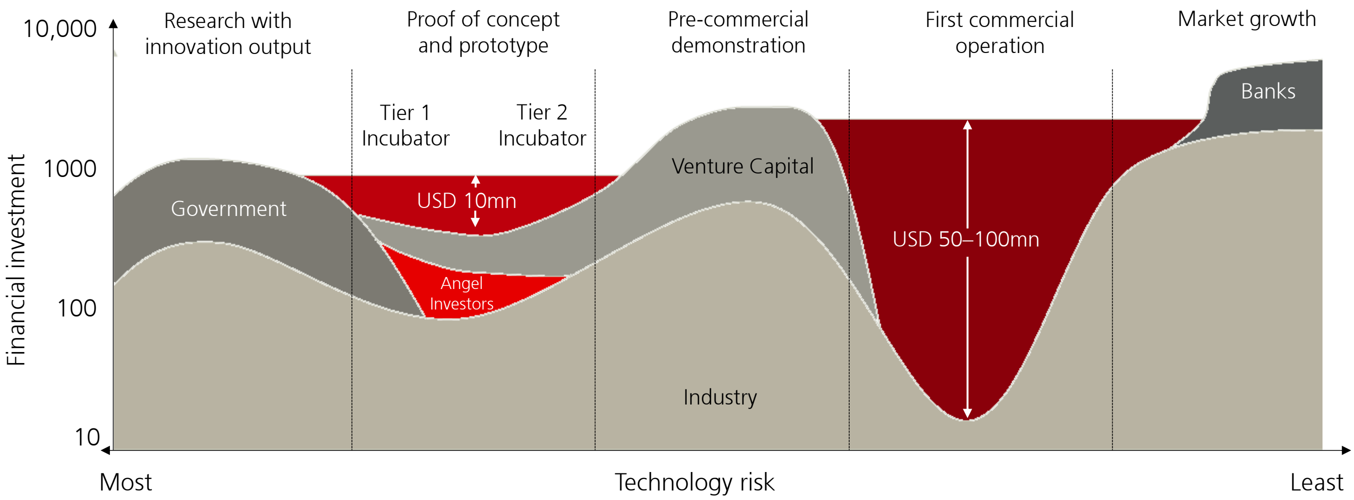
[24] Yearly average investment needs across scenarios between 2023 to 2030 excluding adaptation; values in 2022 USD; Climate Policy Initiative, (2024), Top-down climate finance needs.

[25] Climate tech already experienced this: the so-called "Clean Tech 1.0" between 2006 and 2011, when a range of macro factors combined—cheap gas from shale, falling government support, and China's manufacturing dominance—leading many cleantech startups to fold; this point applies to most technology transitions, as explored in Perez, C., (2003), *Technological revolutions and financial capital: The dynamics of bubbles and golden ages,* Elgar.

[26] Boston Consulting Group, Global Asset Management Sizing Database; *AI and the next wave of transformation,* Exhibit 1.

Figure 3: The sources of capital change as a technology matures

We believe there is enough capital in the world to fund decarbonization; channeling it to climate tech that is moving beyond pre-commercial demonstration and toward commercialization is the challenge



Note: Figures are illustrative.
Source: UBS

The issue boils down to a mismatch between the supply of investable opportunities coming from private markets, and demand as determined by the range of mandates that exist in financial markets. Risky, immature climate techs have little trouble finding investment from risk-tolerant venture capital. The same applies to established, mature climate techs that can easily attract funding from low-risk but deep-pocketed institutional investors.

Those in the middle—moving beyond pre-commercial demonstration and toward commercialization, who suddenly need larger outlays—face a gap. As a result, many capex-intensive climate techs that are crucial to decarbonize high-emitting sectors, such as first-of-a-kind industrial plants, struggle to attract sufficient financing.

Climate techs in the middle are risky. Their costs remain high, technologies unproven at scale, and future demand uncertain. Yet, the mismatch locks them into a Catch-22 where they cannot attract funding due to high technology or demand risk, but they also cannot scale to reduce costs. For example, green steel is more expensive today than conventional steel—to reduce its costs, more factories need to be built to induce learning effects. At the same time, new green steel plants are too high risk for institutional investors and too long-dated and capital-intensive for venture capital firms.

New problems, new solutions

There are two areas requiring innovation to bridge this missing middle. The first is expanding the supply of investable climate tech coming out of private markets. Climate techs in the middle must demonstrate increasingly feasible business models at each capital raise. Done effectively, this can shift them inside the risk-return tolerance of existing mandates, increasing the capital available to them.

The second is enabling more demand from financial markets to invest in climate tech. This involves either enabling existing mandates to invest in risky climate tech through financial innovation that spreads risk; or changing existing mandates to allocate more capital to "the middle." The latter is unlikely over the short to medium term, if at all. Financial mandates by their nature are steady, because they exist to maintain stable financial services. A pension fund requires steady payments to meet regular outgoings to retirees; while they can increase their allocation to alternatives at the margin, they cannot suddenly allocate lots of capital to risky climate techs with irregular and uncertain future cash flows. A recent example is the reticence of sovereign wealth funds to increase the amount they allocate to alternative investments.[27]

In response, new financial innovations are emerging to ensure high-risk ventures can source capital as they scale (Box 4). The key differentiator of these funds from others is the technical expertise they build in the climate techs they focus on. Through hiring engineers and other technical experts, they can build a view on the potential demand, cost, and risk of a climate tech's scaling journey. With a probable risk–return profile established, they can design investment mandates tailored to a climate tech's scaling journey, allowing them to raise capital through each stage.

On top of financial innovation, a new breed of highly active impact investors, philanthropists, and family offices have emerged. They focus on supporting developers to set out business models that address demand or technology risks, enabling them to "cross the middle" (Figure 4). For instance, in several cases impact investors have creatively used their networks to link corporates to climate tech developers, securing advanced market offtake agreements. The agreements effectively create early versions of future supply chains, enabling developers to signal to risk-averse debt providers they can meet future debt repayments. Their use has led to successful "first of a kind" deployments which otherwise wouldn't go ahead. Investor groups also produce targeted, public research that reduces the uncertainty around climate tech's financing journey. A recent example is research from the not-for-profit CREO, which defined a framework for large asset owners and family offices to evaluate the risks of first-of-a-kind climate technologies.[28]

Box 4: New solutions for crossing the "missing middle"

- **Industrial venture capital funds** play an active role in the early stages of climate tech innovation. Recent examples include funds that specifically aim to support moonshot solutions, such as novel materials.[29]
- **Industrial growth funds** support mature climate techs that require large outlays of at least USD 500mn. Examples include technologies with large infrastructure needs, such as hydrogen transport and Direct Air Capture plants.[30]
- **Brown-to-green funds** either buy carbon-intensive assets and directly reduce their emissions, such as real estate funds which target low energy-efficiency buildings, or invest in companies that provide climate tech enabling carbon-intensive assets to decarbonize, such as heat pump manufacturers that enable building decarbonization.

[27] George, L. and Sayegh, H., (2023), *COP28: Sovereign wealth funds struggle to turn their trillions to climate finance*, Reuters.

[28] See CREO, (2024), *The CREO FOAK framework*.

[29] Such as Breakthrough Energy Ventures, which has over USD 3.5bn in committed capital to invest in early-stage climate tech.

[30] Such as the Hy24 platform focused on clean hydrogen infrastructure, and Brookfield Asset Management's recent investments in carbon capture and storage projects.

Figure 4: Two recent successful capital raises in the steel and textiles sector, driven by investor action

		H2 Green Steel	Syre
Climate tech tends to be:	**3 strategies to scale:**	Established in 2020 by a consortium of investors to build the world's first large-scale green steel plant in Sweden.	Joint venture established in 2022 between investor Vargas and H&M to find and scale textile recycling technology. Aims to recycle 3% of global polyester.
More expensive and/or inconvenient than incumbents… →	Accelerate cost falls, improve quality and convenience →	Ideal site to minimize costs of inputs, particularly via long term deal for cheap and abundant Swedish hydropower. Also minimize potential execution risk by siting with good grid and transport infrastructure.	Evaluated ~20 fabric recycling technologies, looking for one that could scale both technology and production quickly to reduce costs. It landed on Premirr, a US start up, which it plans to buy for its recycling technology.
Leading to low demand… →	Reduce demand risk →	Secured contracts with customers who agreed to buy steel when its ready. Half of the initial yearly volumes are already sold. Multiple automakers agreed to buy green steel and act as 'first movers', partly to help meet large Scope 3 climate targets.	H&M agreed an offtake worth USD 600mn, guaranteeing future demand. Investments from furniture and car manufacturers create a basis for more offtakes. Aiming to locate factories in key locations for the textile supply chain.
Creating high risks, and low investment →	Stack and crowd-in investment →	Used concessionary public funding and grants to crowd in private investment. Specifically, it received equity financing an EU body funded by the EU Emission Trading System, and senior debt and credit guarantees from government agencies.	Syre sought initial capital from companies in the fashion, furniture, and automobile industries. Both use large volumes of textiles, and so who have a natural strategic interest to invest in the recycling technology.
	= More "bankable" climate tech projects	Hydrogen-based steel project raised USD 6.5bn in project finance. Planned for 2026.	Closed USD 100mn Series A in 2024 to purchase Premirr's technology and build blueprint US plant. Plans two factories.

Note: H2 Green Steel is now called Stegra.
Source: UBS

2. Tracking breakthroughs

At a glance

- Tracking the proximity of climate techs to tipping points informs strategic policy, investment, and organizational decisions.
- We propose a 3-part framework: It establishes *what* each tech's impact and commercial opportunities are; *how* they are developing and scaling toward these goals; and *why* they may, or may not, present an opportunity to drive the transition in the short term.
- For some, this lens will help them respond effectively to the transition. For others, it will help drive it.

New technologies deploy quickly when they become economically competitive with incumbents, piggybacking on existing market forces to rapidly deploy. Few studies apply the tipping point lens to climate change, fostering a mainstream underappreciation of decarbonization as a technology-led growth story.

The framework

We developed a 3-part framework that provides a *what*, *how*, and *why* for each climate tech: *What* each tech should aim for in terms of deployment and emissions reduction impact; *how* it can become commercially competitive to achieve those goals; and *why* it may or may not be moving toward a positive tipping point.[31]

First, it defines the deployment goal for each technology over the next decade—aligned roughly to below 2°C warming—and the potential GHG emissions reductions this implies. Second, it defines the opportunity this goal presents in terms of total addressable market, and the implementation cost. Third, it assesses how far each technology is from meeting its deployment goal by evaluating its commercial maturity, via four criteria: cost, compensation, convenience, and compatibility (Box 5) adding up to a "commercial maturity" score. Finally, we rank each climate tech based on an aggregate transition opportunity score, which reflects its potential impact, the commercial opportunity, and how far it is from achieving that potential. Applying this approach—stand alone or in combination with others—can help those who want to drive the transition

[31] See our companion report, *Climate tech passports,* for the methodology and detailed analysis. If each of the 15 techs analyzed in that report were fully deployed, they could reduce, avoid, or remove about 200 gigatons of GHG emissions—enough to meet roughly 70% of the 1.5 °C carbon budget.

with their capital by prioritizing those techs with both a high abatement potential and proximity to a commercial tipping point.

Box 5: The four Cs framework for evaluating a tech's commercial maturity

Novel technologies moving from slow to exponential growth have common attributes. Meeting them signals commercial maturity and readiness to scale, providing a yardstick to judge whether a new technology is on the verge of breaking through. We structure these common attributes as the "Four Cs":

- **Cost:** Once a solution becomes cost competitive with incumbents, rapid deployment often follows. In the 1960s, once cheap natural gas was discovered in the North Sea, it supplanted coal in the UK within 30 years.
- **Compensation:** Generating revenue and eventually profits—the hallmark of technologies with effective business models—depends on more than falling costs, such as proven business models, and the nature of markets and policy support. For instance, wind energy is cheap today, but investment can suddenly drop if relative profitability suffers, such as through an end to subsidies, or if revenues are too volatile to assuage capital lenders of a project's risks.[32] Even if a technology is cheap, it may struggle to generate consistent reliable revenues, requiring further innovation to find a reliable product-market fit.
- **Convenience:** Non-cost features such as higher quality, better reliability, or new capabilities increase a technology's convenience, and therefore commercial maturity. For instance, climate techs inherently reduce emissions, and so they can enjoy a "green halo" effect in market segments where this enhances their perceived quality. Wider trends can also render a technology more attractive to consumers, such as if social norms shift in favor of alternative proteins.
- **Compatibility:** A technology's growth could be limited by broader factors beyond its control that act as a bottleneck on deployment. Current examples among climate techs include renewables' struggle to connect to electricity grids due to infrastructural bottle necks, and consumers remaining resistant to buying EVs in some places due to a lack of public charging stations.

Quantitatively comparing the current state and future direction of technologies is difficult. This is why most analyses adopt a rating-style approach.[33] We use a similar method; a solution's aggregated score across each C determines its relative commercial maturity, providing a yardstick for its proximity to a deployment tipping point. A climate tech is commercially mature if it is cheap, generating reliable revenues, better quality than incumbents, and doesn't face steep infrastructure or supply-side bottlenecks.

While decarbonization requires a portfolio of solutions, in most high-emitting sectors there is often one or two that will provide the bulk of supply-side decarbonization. For instance, while decarbonizing shipping requires multiple levers, zero-carbon fuels like green ammonia and methanol are expected to account for around 80%.[34] We prioritized key solutions to keep the analysis focused by choosing technologies that are both included in mainstream Net Zero scenarios and have adequate public data to track progress on a global level. Our analysis draws three conclusions.

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[32] Rapidly growing revenue signals a deployment turning point—semiconductors, for instance, have experienced rapid demand in recent years, translating to large revenues for manufacturers—and plateauing revenue implies market saturation. For a wider discussion in the context of wind and solar energy, see Christophers, B., (2024), *The price is wrong: Why capitalism won't save the planet,* Verso Books.

[33] Similar approaches to compare climate techs have been used across the private sector; see Flowers, M. et al (2024), *The coming low carbon energy disruptors,* Wood Mackenzie; SystemIQ et al (2023), *The breakthrough effect: How tipping points can accelerate net zero*

[34] UMAS, (2020), *A strategy for the transition to zero-emission shipping.*

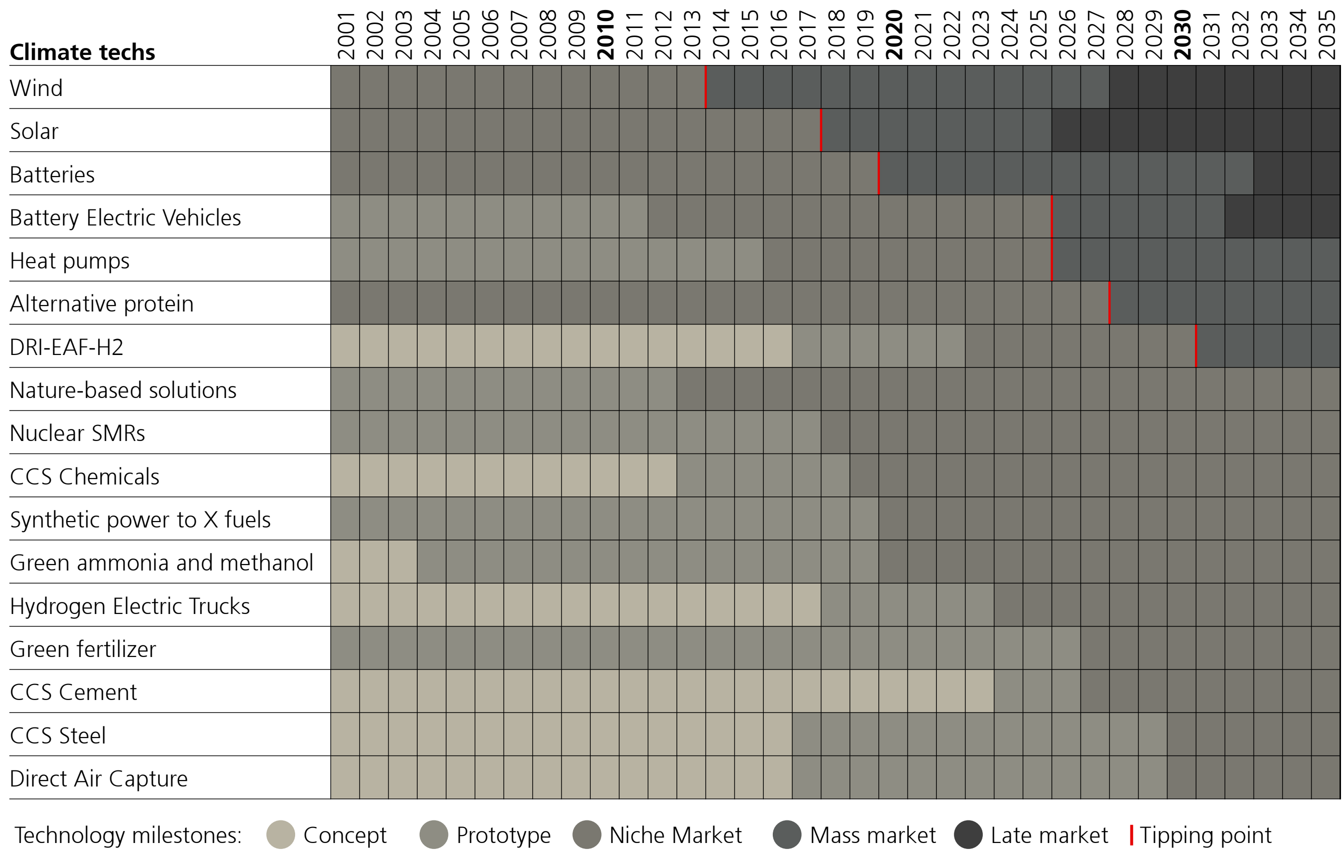
1) Tipping points are approaching for some sectors. For others, they lie beyond 2035.

If each of our analyzed climate techs were fully deployed in line with the goals of the Paris Agreement, they could reduce, avoid, or remove around 200 gigatons of GHG emissions—enough to increase the 1.5 °C carbon budget by around 70%.[35] While they will not deliver Net Zero, together they offer powerful levers to deliver most of the decarbonization needed over the next decade.

Several climate techs are fast approaching, or already have likely passed, such tipping points where they may begin rapidly outcompeting incumbents (Figure 5), such as solar PV, wind, and utility-scale batteries. Their momentum is strong and growing stronger. Other important technologies may pass tipping points before 2030, including battery electric vehicles and trucks, as well as heat pumps.

Figure 5: Climate techs could trigger multiple tipping points in the 2020s

Several climate techs are close to such tipping points where they may begin rapidly outcompeting incumbents



Notes: Market stages are identified as a mix of cost competitiveness as well as expected market penetration.
Source: UBS

However, several key technologies remain far away from the mainstream, with their likely tipping point beyond 2035. Engineered carbon removals, such as Direct Air capture, or Carbon Capture and Storage attached to a factory, will be essential tools to remove carbon from the atmosphere, particularly in the 2040s. Scaling them fast enough requires rapid improvements in cost and sustained investment to bring forward the move from niche to mass market.

[35] The latest 1.5 °C carbon budget is 275 $GTCO_2$, as per GlobalCarbonBudget (2024).

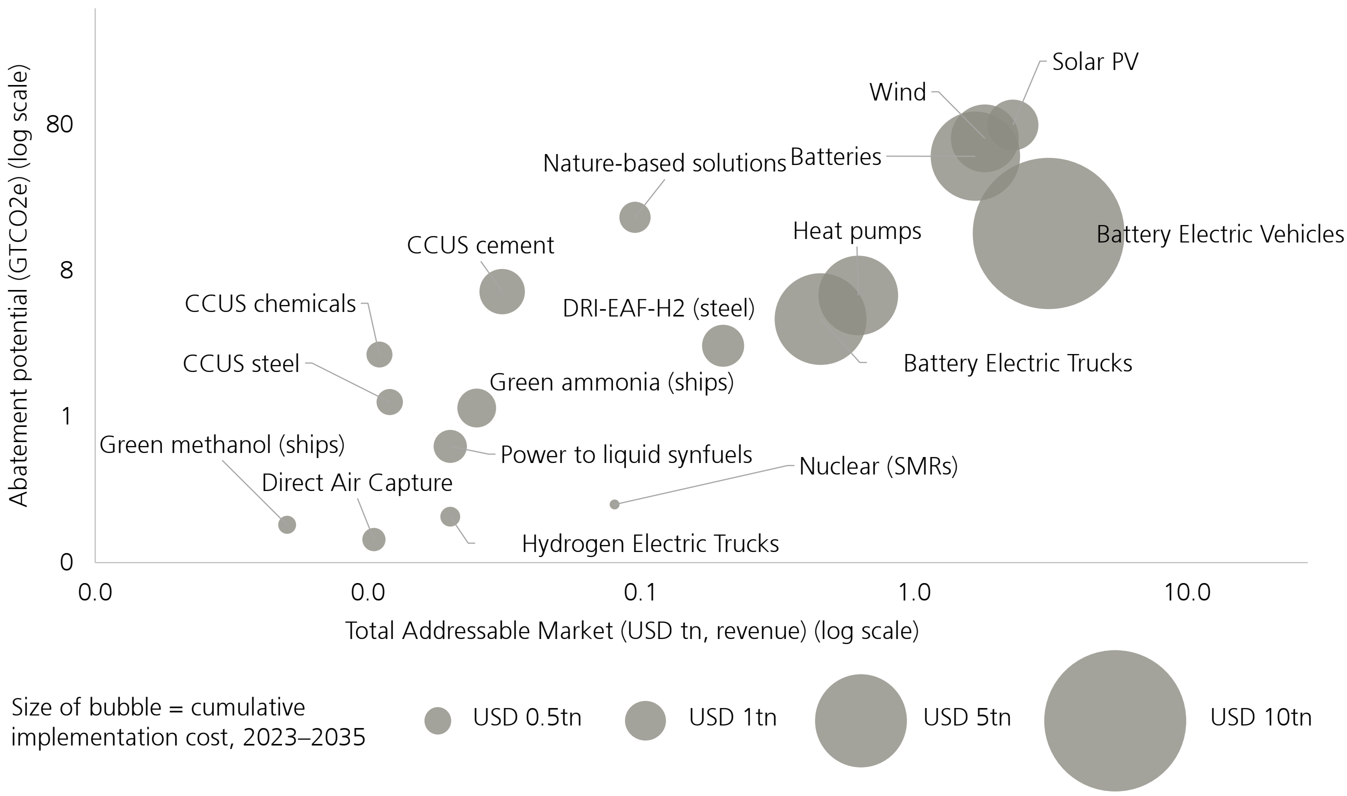
2) Climate technologies require significant investment, but some offer greater abatement.

Reaching deployment targets in-line with climate goals over the next decade will cost trillions of dollars in cumulative investment. This is mostly driven by climate techs that are already mature; Net Zero scenarios expect these solutions to deploy quickly over the next decade, meaning they have a much higher short-run implementation costs. Less mature solutions, such as Hydrogen Electric Trucks, remain expensive in the near-term, and so only scale from the late 2030s.

While the expense may be daunting, climate techs with the largest implementation costs by 2035, such as wind, solar, and battery electric vehicles, also have the largest potential to reduce emissions (Figure 6). A large build out of any solution naturally means it enjoys a potentially large market with significant revenue flows and value pools if they scale in-line with climate targets.

Figure 6: Climate technologies with the highest cost provide the greatest bang-for-the-buck

Those with the largest implementation costs by 2035, such as wind, also offer significant emission reductions



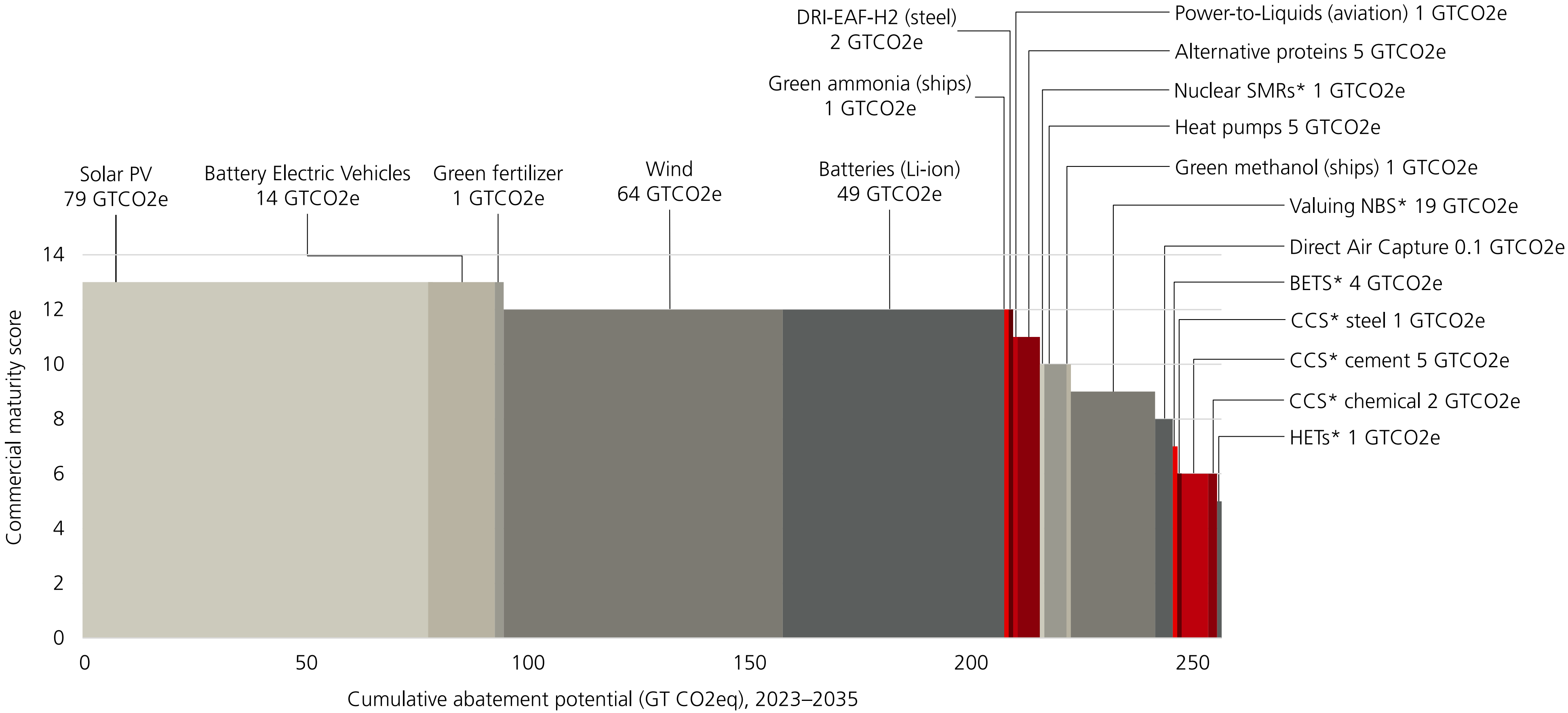
Source: UBS

3) Impactful technologies are those close to tipping points with high abatement potential.

Climate techs that are close to tipping points and offer high emissions savings present compelling opportunities to reduce emissions for minimal effort (Figure 7). Small improvements in price or quality could tip them into economic competitiveness, resulting in rapid deployment and significantly reduced GHG emissions. EVs, for example, are a mature technology where price parity with conventional cars is expected soon, and each additional EV displaces emissions-intensive ICEs, generating significant GHG savings. Focusing reform, resources, and capital on bringing forward tipping points for these technologies is possibly the most efficient way to quickly reduce emissions over the next decade.

Figure 7: High commercial maturity and abatement potential offer good bang-for-the-buck

EVs, for example, are a relatively mature technology where price parity with conventional cars is expected in the next few years



Notes: Commercial maturity score is the sum of a technology's score against each pillar of the four C's framework (out of 20), indicating proximity to a competitiveness tipping point (see the companion climate tech passports for more details); DRI-EAF-H2 = Direct Reduced Iron processed in an Electric Arc Furnace, fuelled by Hydrogen; SMRs = Small Modular Reactors; NBS = Nature-based solutions; CCS = Carbon Capture and Storage; BETs = Battery Electric Trucks; HETs = Hydrogen Electric Trucks; Abatement potential below 1 are rounded up for the visual; Assumes batteries facilitate 30% of electrified transport and power abatement.
Source: UBS

Summing up

1. Climate goals require mass-scale deployment of climate technologies—a process of “better” low-carbon solutions replacing “worse” carbon-intensive incumbents.

2. The journey has already kicked off in the power sector, and it is fast approaching in the road transport sector. Yet, this highlights a key sticking point: most climate technologies today remain commercially uncompetitive, stifling their rollout.

3. The world is familiar with technology breakthroughs. It should use the recent move from big to small tent approaches to strengthen the hand of climate techs, engineering tipping points to deploy them faster up classic S-curves of adoption. A capital-hungry process, financial markets, and innovation will be a key enabler.

4. We propose a 3-part framework to track the proximity of key climate techs to their tipping points. For each solution, it establishes a deployment goal, the necessary conditions to meet that goal, and why the technology may or may not present an opportunity to drive the transition in the near term. The findings can inform strategic policy, investment, and organizational decisions as the world decarbonizes.

5. We estimate that just 15 key climate technologies could generate around 200 $GTCO_{2e}$ of GHG emissions savings by 2035 if globally deployed—enough to meet 70% of the latest 1.5°C carbon budget.[36] Solutions that offer high abatement potential and face near-term tipping points offer the highest bang-for-the-buck in terms of GHG reductions and potential growth opportunities.

[36] Please see our companion report, *Climate tech passports*, for the methodology and analysis.

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