PitchBook

PitchBook Data, Inc.

Nizar Tarhuni Executive Vice President of Research and Market Intelligence

Paul Condra Head of Emerging Technology Research

Institutional Research Group

Analysis

John MacDonagh
Senior Analyst, Emerging Technology
john.macdonagh@pitchbook.com

Data

Oscar Allaway
Data Analyst

pbinstitutionalresearch@pitchbook.com

Publishing

Designed by **Megan Woodard**

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EMERGING TECH RESEARCH

Climate Tech Software

Software offerings are a key component of overall decarbonization

PitchBook is a Morningstar company providing the most comprehensive, most accurate, and hard-to-find data for professionals doing business in the private markets.

Key takeaways

- Software technologies are a core component of the climate tech space, though more mature technologies such as solar and wind energy are more widely associated with it. Climate tech startups can focus on hardware or software exclusively, but many operate somewhere in between, creating hardware and software to interface with climate tech. Reaching decarbonization targets will require a combination of software and hardware technologies.

- Some investors may favor software investments for several reasons, including their own experience in software investments, the faster time to market and scaling, fewer supply chain concerns, more available talent, and fewer regulatory and permitting challenges.

- From 2021 to 2023, annual VC investment into climate tech software startups was stable at $5.8 billion, but as of November 2024, climate tech software companies have raised $4 billion in VC deal value YTD—full-year deal value will fall below the previous three years.

- The carbon accounting space is one of the larger categories for climate tech software, though competition in the space is strong, with incumbents providing broad offerings with modules to cover a range of client types. Some new entrants are focusing on providing deeper coverage for specific industries, thus avoiding direct competition.

- Within the climate tech software space, companies with valuations over $1 billion are not concentrated in specific segments and include Watershed in the carbon accounting category, Xpansiv in the voluntary carbon market infrastructure category, and KoBold Metals in the green mining category. We may see further valuations above $1 billion in the carbon accounting category, or potentially those developing building energy management systems, given the technology's potential to provide benefits outside of climate concerns via reduction of energy consumption and therefore costs.

- Core climate and Earth data technologies are still in demand, though providers that do not take advantage of advanced sensing and analytics technologies are potentially at risk of falling behind newer entrants to the space. Many of the more established providers are working to expand their offerings though, while newer startups are developing niche products that focus on a specific dataset.

Introduction

The climate tech space is highly varied in terms of industries, applications, and technologies. Climate change mitigation is often considered a hardware problem and thus associated with large hardware projects such as solar farms, utility-scale energy storage, nuclear energy projects, and carbon capture facilities, but the space also includes a suite of software and services. In 2023, we tracked $44.5 billion in VC deal value raised by climate tech startups overall and $5.8 billion raised by climate tech startups that develop software offerings. This analyst note focuses on this subset of climate tech companies that develop software components and solutions for climate change mitigation. Though some companies focus exclusively on either hardware or software, most fall somewhere in between, and with this in mind, this note includes those that develop mixed hardware and software technologies, as long as software makes up a significant component.

Software-focused startups are somewhat concentrated in certain climate tech categories, including:

- **Carbon accounting/analytics:** This category has had the most software-focused VC deals since 2020 and consists of platforms to analyze the carbon profiles of an entity—typically a company, but also groups and individuals. These offerings frequently include additional features to manage carbon emissions offsetting, including planning, carbon project discovery, and marketplace integration.

- **Analytics & grid management:** Software technologies for analytics & grid management commonly focus on grid-scale energy management, optimization, and integration with power grids' electricity trading market. These platforms can allow clean energy to be integrated into power networks more efficiently, reducing the challenges caused by intermittency or by optimization of battery energy storage systems, depending on the purpose of the installation, whether it is peak shaving, managing renewable energy intermittency, ensuring business continuity, energy arbitrage, or a combination of these purposes.

- **Building energy efficiency:** Technologies to improve the energy efficiency of buildings typically include a combination of hardware and software, with many of the largest VC-backed companies developing these technologies providing an all-in-one offering that integrates with existing electrical hardware, acts as a central energy management system, and—depending on client needs—incorporates and optimizes energy generation and storage hardware. Local energy generation and storage hardware can improve a building's energy usage and carbon footprint, but optimization software can augment this substantially by maximizing the

use of self-generated clean energy when electricity prices are highest. In some instances, these offerings can integrate with power grids, allowing users to participate in demand response mechanisms to assist in balancing power grids or trade excess energy from their solar equipment.

- **Climate/Earth data:** Sensing and monitoring technologies are used for a variety of climate technology applications and are often flexible in their usage—companies developing these technologies often serve clients in a broad range of sectors, including agriculture, forestry, insurance, defense, and energy. Software components are required to process and analyze the very large datasets that continuously monitoring sensors can produce.

Outside of the climate tech categories that lean most heavily toward software technologies, categories that are commonly hardware focused—such as solar and wind energy—also contain software-focused companies that address specific applications within these categories. In the case of solar and wind energy, while most companies in the space develop and produce physical components such as solar modules and panels, several software-focused niches exist, including digital twin technologies for monitoring and maintenance, solar tracking and hail avoidance technology, and solar planning tools for optimizing solar project installation—particularly on uneven terrain with varying elevation. Similarly, technologies for reducing carbon emissions from industrial facilities include thermal energy storage and green chemical inputs, such as hydrogen, but they also include software technologies for analyzing facilities' energy usage and either providing recommendations for lowering energy consumption or wasted energy or controlling systems in the facility in a more energy-efficient way.

Challenges for hardware startups

From an investor perspective, climate tech software and hardware represent very different opportunities. Though some elements of climate tech hardware are very much mature, such as most wind and solar energy technologies, many are still nascent and can be considered deep tech: technologies that require significant innovation, with substantial scientific and engineering challenges. Developing decarbonization technologies in some climate tech categories—such as energy generation and storage, low-carbon mining, or carbon capture and storage—frequently involves a series of increasingly complex testing and demonstration projects followed by large commercial-scale physical installations. These characteristics result in certain challenges that affect hardware startups more strongly than software startups:

- **Capital requirements:** Developing climate tech hardware generally requires significantly more capital due to higher requirements for land; manufacturing and production facilities; and physical infrastructure, such as demonstration projects, grid connections, and supply chain infrastructure. Nuclear energy projects are particularly known for high capital requirements due to their complexity, size, and regulatory/safety requirements, as are geothermal and carbon storage projects because of their need for complex geoengineering.

- **Deployment times:** Hardware-focused climate tech startups commonly develop a series of projects that initially provide a lab-scale proof of concept, and then they iterate toward commercial-scale projects, whether these are manufacturing facilities or installations of the company's hardware. These projects are necessary to showcase technological effectiveness and unit economics at both small and large scales, and environmental compliance. Earlier-stage companies are typically more exposed to these challenges, facing the "valley of death" between initial investment and revenue generation—for climate tech hardware startups, this period can be extended due to the requirement for testing and demonstration facilities and the various permitting stages. During this pre-revenue scale-up, startups look to sign contracts with future clients. Target dates for specific milestones in these contracts can introduce risk due to long deployment times, and the failure to meet key milestones can result in termination of these contracts. In June 2024, BMW canceled its $2.2 billion order for battery cells from Northvolt, citing Northvolt's inability to deliver this order on time.[1] In November 2024, Northvolt sought Chapter 11 protection in the US.[2]

- **Supply chains:** The COVID-19 pandemic highlighted the importance of effective supply chains, and climate tech hardware is strongly exposed to supply chain risks, which affect raw materials such as copper, lithium, cobalt, and nickel and components such as solar modules, wind turbine blades, and batteries. Some of these supply chains are highly dependent on specific regions or countries, including China, which dominates solar photovoltaics, batteries, wind energy hardware, and electrolyzers,[3] and Congo, which mined 69% of the world's cobalt in 2020.[4]

- **Regulation and permitting:** Energy projects face significant regulation and permitting requirements due to their potential to disrupt tightly controlled power grids, and as a result, they require analysis of their impacts on grid operation before their construction. Additionally, these projects are often located where the conditions (wind speeds, annual solar irradiance, and so on) are most suitable, which can place them in natural ecosystems, thereby requiring extensive environmental impact analysis. Carbon storage projects are also highly exposed to a long permitting process due to the frequent necessity of constructing such projects in locations with favorable geology rather than in areas that are less challenging from a permitting perspective.

These challenges complicate the evaluation of companies developing hardware for climate change mitigation and introduce risk for investors. For this reason, nonspecialist climate tech investors may favor software-focused startups because they have more familiarity with the business models, regulation, and underlying engineering and technology involved.

Compared with hardware-focused startups, those primarily focused on software have lower requirements for up-front capital and can be brought to market faster with far less challenging supply chains. In addition to their faster time to market,

1: "BMW Cancels $2 Bln Battery Cells Contract With Northvolt," Reuters, June 20, 2024.
2: "Northvolt Takes Major Actions to Support and Enhance Homegrown Battery Production Platform," Northvolt, November 21, 2024.
3: "Clean Energy Supply Chains Vulnerabilities," IEA, January 2023.
4: "One Hundred Years of Cobalt Production in the Democratic Republic of the Congo," Elsevier, Resources Policy, Andrew L. Gulley, December 2022.

software offerings are also generally faster to adapt and iterate upon, which can be particularly beneficial in the climate tech space due to rapidly evolving regulation and policy. Depending on the specific subsector, hardware-focused climate tech can face more challenges from a talent perspective—though skills from related fields can simplify retraining, sourcing talent for constructing and operating new physical hardware can be more time-consuming than for software-based applications. These challenges facing hardware-focused climate tech startups can make it difficult to go to market but can also be beneficial for those able to overcome them, as the barrier to entry and high demand for hardware can provide a competitive advantage.

VC activity

VC investment into climate tech software startups was stable from 2021 to 2023, during which it remained stable at $5.8 billion—the high-water mark for the space. As of November 2024, climate tech software companies have raised $4 billion in VC deal value YTD, suggesting that full-year deal value will fall below the previous three years. Since 2017, VC deal value for climate tech software has been flatter than VC deal value for the overall climate technology space, ranging from $2.2 billion in 2017 to $5.8 billion in 2023. Looking at trailing 12-month (TTM) deal value, five segments within climate tech software raised more than $400 million:

- Carbon tech: $814.5 million.
- Industry: $729.6 million.
- Grid infrastructure: $705.4 million.
- Land use: $616.8 million.
- Built environment: $467.6 million.

The carbon tech segment is most heavily represented by carbon accounting platforms and carbon fintech startups and has the highest TTM deal count by a considerable margin, at 152 deals. The industry segment has the next highest VC deal value, though with far fewer deals than the carbon tech segment, with only 52 deals in the past 12 months. The segment's high VC deal value is driven partially by KoBold Metals' $491.5 million Series C round, which is the largest climate tech software deal of 2024 thus far. KoBold Metals develops AI systems to locate mineral deposits, providing mineral resources needed for the energy transition and resulting in lower environmental impacts to mining sites.

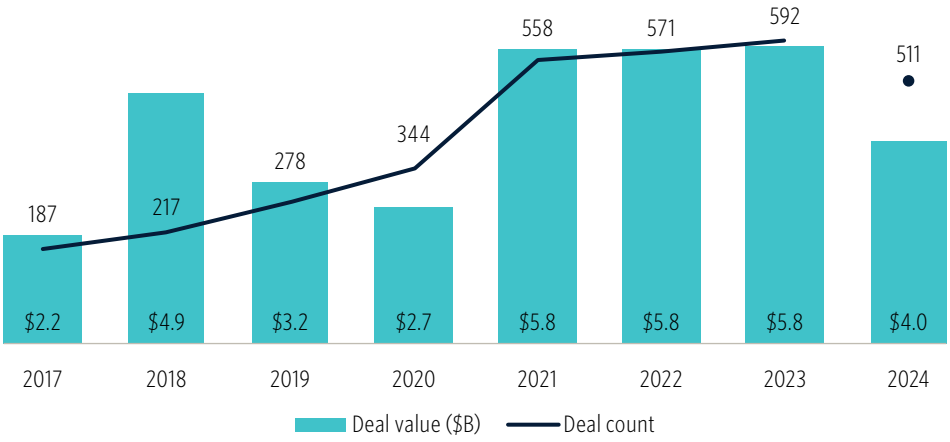
By region, North America has led in climate tech software VC deal value every year since 2018, with the second-largest region by VC deal value switching from Asia to Europe from 2020 onward. In 2023, North America represented more than 50% of total VC deal value in climate tech software. Europe's deal count in the space has been the highest of all regions every year since 2020, but the median deal value in Europe is considerably lower than in North America—the 2023 median deal value in Europe was $2.2 million, compared with $4.8 million in North America. The global median deal value has been trending upward, from $1.8 million in 2019 to $4 million so far in 2024, with a dip to $3 million in 2023. Looking at the median deal value by stage, the median late-stage VC deal value has remained mostly flat since 2021, varying from $7.2 million to $8 million during this period, while the median early-

stage VC deal value fell substantially from $5 million in 2022 to $2.4 million in 2023. The overall median pre-money valuation has been rising from $6.8 million in 2019 to $18 million so far in 2024.

In addition to KoBold Metals' $491.5 million Series C, two deals exceeded $100 million: Monarch Tractor's $133 million Series C and Exodigo's $105 million Series A. Similarly to KoBold Metals, Exodigo also develops subsurface mapping technology, though it is more focused on energy, utility, and transport infrastructure rather than mineral exploration. Monarch Tractor develops a combination of hardware and software, offering autonomous electric tractors in addition to the company's WingspanAI platform, which provides control and monitoring of the company's vehicles, including fleet management, performance monitoring, and maintenance data capture.

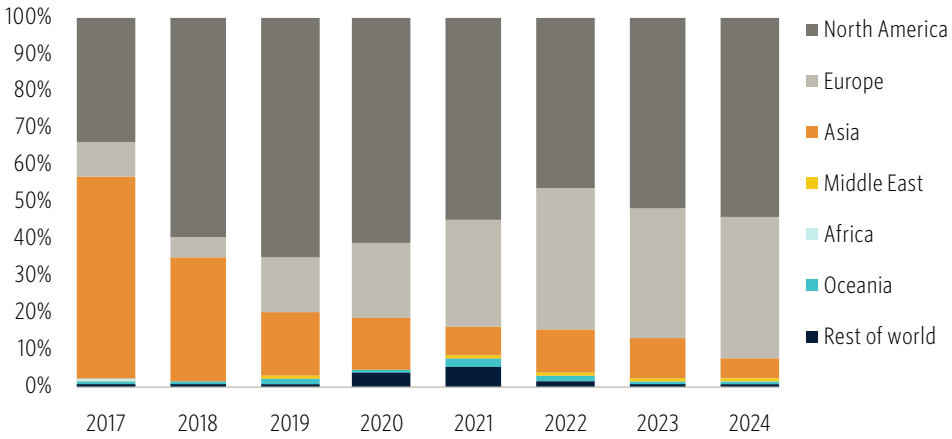
VC exit activity for climate tech software shows similar trends to the overall climate tech VC space, with a large spike in exit activity of $8.3 billion in 2021 and $8.8 billion in 2022—which coincided with strong market conditions—before falling sharply to pre-2021 levels in 2023 with only $0.3 billion. So far in 2024, we have seen $1.2 billion in VC exit activity, with Human Horizons' $1 billion acquisition being the largest exit. The company focuses on a combination of electric vehicles, autonomous driving, and smart city technology.

Climate tech software VC deal activity



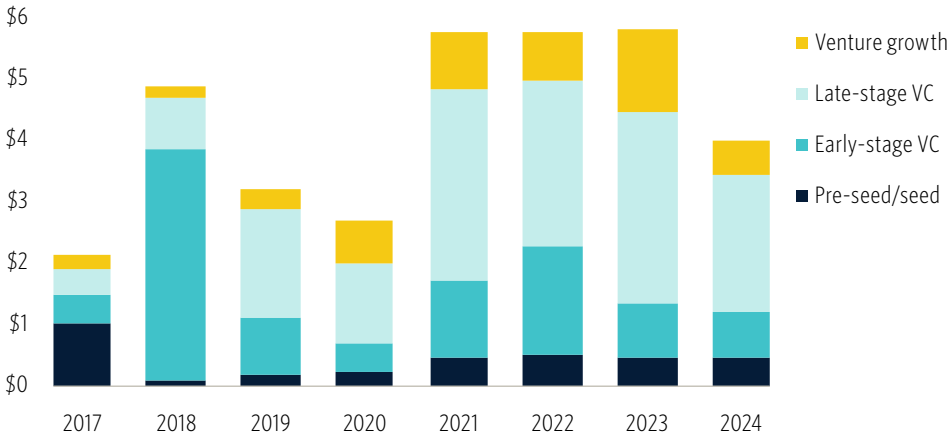
Source: PitchBook • Geography: Global • As of November 25, 2024

Share of climate tech software VC deal value by region



Source: PitchBook • Geography: Global • As of November 25, 2024

Climate tech software VC deal value ($B) by stage



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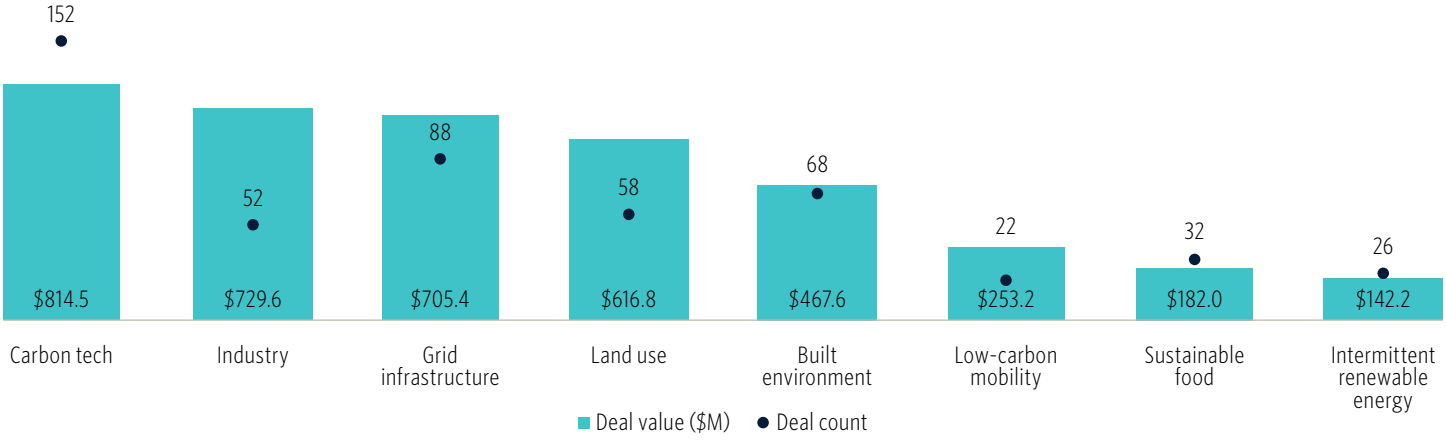
TTM climate tech software VC deal activity by segment



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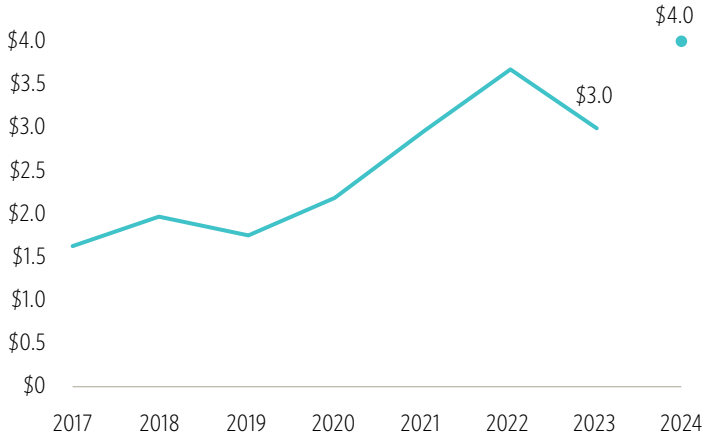
Note: Chart only includes segments that raised more than $100 million in the trailing 12 months.

Median climate tech software VC deal value ($M)



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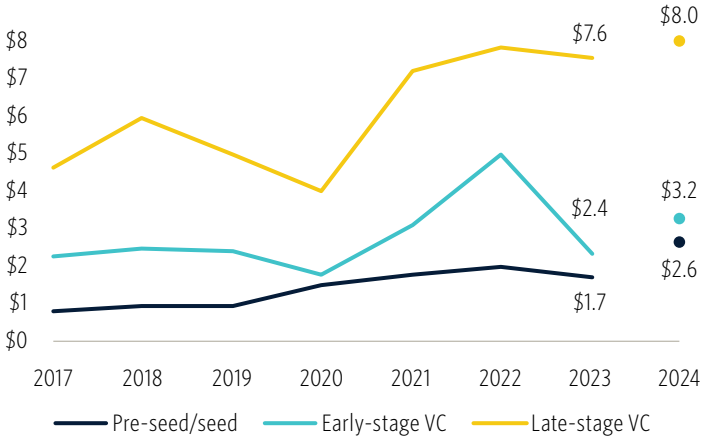
Median climate tech software VC deal value ($M) by stage



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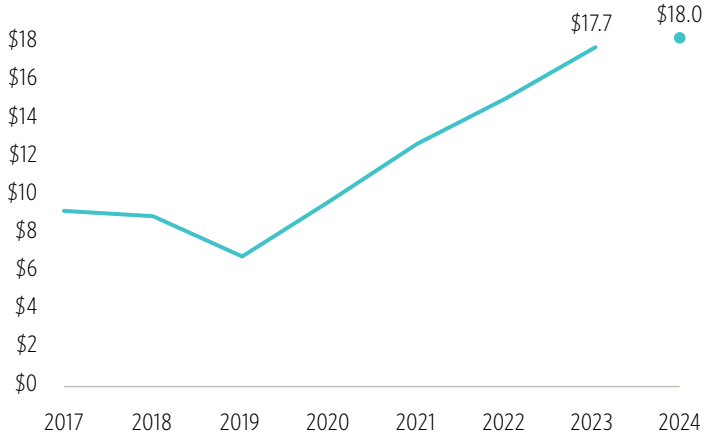
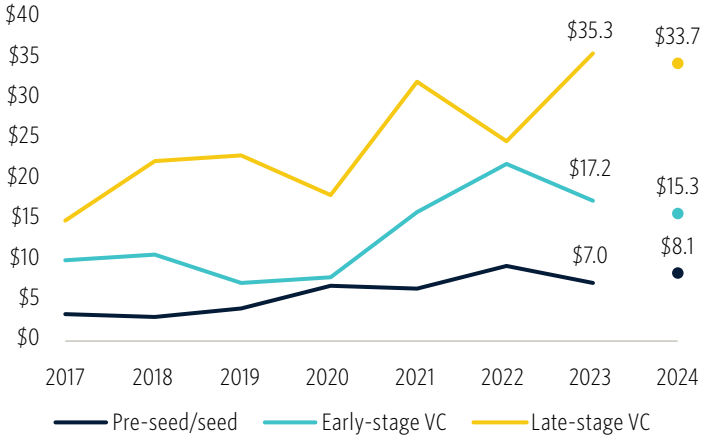
Median climate tech software VC pre-money valuation ($M)



Source: PitchBook • Geography: Global • As of November 25, 2024

Median climate tech software VC pre-money valuation ($M) by stage



Source: PitchBook • Geography: Global • As of November 25, 2024

Key areas for climate tech software

Carbon accounting

In order to manage or report on carbon emissions, companies need to be able to accurately measure them, which can be a complex process. Demand for carbon accounting is driven by several factors, including investor pressure, consumer pressure, climate disclosure requirements, and carbon pricing schemes. Of these drivers, some are region specific—climate disclosure requirements and carbon pricing schemes depend heavily on regional regulation and policy, exposing the segment to some risk from regulatory change. Investor and consumer pressures are more static drivers of interest in carbon accounting platforms and can provide justification for buyers when compliance requirements are uncertain.

Carbon accounting software varies in its coverage in terms of emissions "scope" and the sector or entity type that it is suited to. The three carbon emissions scopes are:

- **Scope 1 emissions:** Emissions directly emitted from the organization, such as those from burning natural gas for industrial purposes or from internal combustion engines in vehicle fleets.

- **Scope 2 emissions:** Indirect emissions from energy usage, such as the emissions from conventionally produced electricity.

- **Scope 3 emissions:** Indirect emissions from elsewhere in the company's supply chains, including emissions associated with raw materials or manufactured product inputs. This essentially includes all emissions outside of Scope 1 and 2 emissions.

Most carbon accounting platforms cover Scope 1 and 2 emissions, with some also covering Scope 3. Calculating Scope 1 and 2 emissions is more straightforward than calculating Scope 3 emissions and requires analysis of the organization's electricity consumption; fuel usage; and in certain sectors, industrial carbon emissions. Scope 3 emissions are more complex to calculate, as they require analysis of every input and output in a company's value chain and calculation of the embodied emissions of each item—some of which will depend on factors such as point of origin, transportation, supplier, and production method. We are seeing the emergence of some carbon accounting startups that specialize in specific industries to allow for more accurate calculation of these value-chain-specific emissions. In general, these specialists tend to focus on industries that have complex value chains. This includes the food industry—with most startups concentrated in Europe, such as CarbonCloud, Root Global, and Carbon Maps—and the supply chain industry, which includes startups such as Pledge and Clearly.

The largest VC-backed carbon accounting companies by total raised are Watershed, Measurabl, Persefoni, and Sweep, which all provide broad carbon accounting platforms suited to a range of client types, including enterprise and midmarket companies and financial institutions. Watershed offers additional industry-specific capabilities covering the food and beverage industry and retail and apparel sectors.

VC-backed carbon accounting companies have raised $485 million so far in 2024, which slightly exceeds the $484.7 million raised in 2023. In 2024, nine deals have had a value greater than $10 million, with the deals split between US- and Europe-headquartered companies. Buyers of carbon accounting platforms often like to choose an offering within their own geography for closer alignment of reporting requirements and supply chain carbon characteristics, though larger platforms often cover several geographies.

Battery management systems

Clean energy installation is growing, but the most prevalent technologies for this are solar and wind energy, which both produce variable outputs depending on local conditions. When these technologies are a small component of overall energy generation, this intermittency can be managed through standard power-grid-balancing approaches, including demand response mechanisms, which increase power output or decrease power consumption when electricity demand is very high. These intermittent resources are a growing component of overall energy systems, and with this, additional approaches to balancing power grids are becoming more desirable. Battery energy storage is one of the most viable options for managing power grid stability, as battery prices have fallen due to widespread development of battery technologies in the energy, mobility, and consumer industries.

Outside of battery installations for managing the intermittency characteristics of renewable energy installations, other use cases include protection from power network disruption; improving industrial or residential energy efficiency; and battery arbitrage, where batteries are charged when electricity prices are low and the energy is sold when electricity prices are high, during peak demand. Battery arbitrage is typically seen in regions with high electricity price variance, such as Texas.

Software in the battery technology space plays a critical role in controlling and monitoring battery installations, and companies in the battery space mostly fall into one of two categories: those that manufacture cells for integration into other products, and those that develop combined hardware and software products. The software component of these manages when the battery charges and discharges and optimizes this cycle based on the type of installation and its end goals. This can involve connecting to external data feeds, such as power grid load forecasts and renewable energy generation forecasts, to deliver power when demand is high and low operational cost sources such as renewables are not able to increase their output. For industrial and commercial or residential applications, battery management systems can learn the typical energy consumption profile for the facility or building and optimize battery use to reduce the need for grid power at times that local renewable energy output is low or provide energy when grid electricity costs are highest.

An additional function of battery management software is monitoring and diagnostics. Lithium-ion cells can be damaged or lose capacity over time if used improperly, which can mean maintaining temperatures within a defined range or preventing overcharging or overdischarging. Management systems monitor conditions and manage usage of cells in the installation to maximize lifespan and

can also monitor for problems with specific cells, which is particularly important if those cells are a risk to the whole installation. The monitoring systems in place can also link to fire detection and suppression capabilities, which can allow infrastructure to be disconnected in the event of a fire and alert facility managers. High-profile fires at grid-scale battery energy storage systems (BESS) are not unheard of and can damage perceptions of energy storage technologies. High-profile BESS fires in the past few years include a 2023 incident at a Tesla Megapack in the Bouldercombe Battery Project in Queensland, Australia,[5] and a 2024 incident at the Gateway Energy Storage in California.[6]

Though most BESS are created from new cells, stationary energy storage is a key application for second-life cells, typically from mobility applications. Once electric vehicle batteries have degraded to the point that their reduced range is not viable, they can be repurposed for stationary applications, where volume can make up for lower performance. In these instances, effective monitoring and diagnostics are even more important because the cells in a BESS unit may have different characteristics due to their different usage histories.

5: "Tesla Megapack on Fire in 'Minor Incident' at Battery Storage Site in Australia," Energy Storage News, Andy Colthorpe, September 27, 2023.
6: "Fire Burns for Five Days at Huge Lithium-Ion Energy Storage Facility," Recharge, Cosmo Sanderson, May 20, 2024.