



Chapter 3 Technical Annex

Gregory F. Nemet (University of Wisconsin-Madison)

Morgan R. Edwards (University of Wisconsin-Madison)

Oliver Akeret (ETH Zurich)

Jenna H. Greene (University of Wisconsin-Madison)

Franklyn Kanyako (University of Wisconsin-Madison)

Kathleen Kennedy (University of Maryland)

Kavita Surana (Vienna University of Economics and Business)

Zachary H. Thomas (University of Wisconsin-Madison)

Felix Creutzig (Potsdam Institute for Climate Impact Research, PIK)

Sabine Fuss (Potsdam Institute for Climate Impact Research, PIK)

Konish Naidu (United Nations Environment Programme)

Quirina Rodriguez Mendez (Potsdam Institute for Climate Impact Research, PIK)

Chapter scientist: *Franklyn Kanyako (University of Wisconsin-Madison)*

Cite as: *Nemet, G. F., Edwards, M. R., Akeret, O., Greene, J. H., Kanyako, F., Kennedy, K., Surana, K., Thomas, Z. H., Creutzig, F., Fuss, S., Naidu, K., Rodriguez Mendez, Q. Chapter 3: Demonstration and upscaling, in **The State of Carbon Dioxide Removal 3rd Edition 2026** (eds. Edwards, M. R. et al.). DOI: <https://doi.org/10.17605/OSF.IO/82XV6> (2026)*

Technical Annex | Chapter 3

A3.1 Demonstration project funding and tracking

This report uses data on demonstration projects from three sources to build a dataset on CDR demonstration projects worldwide. The first source is the Carbon Dioxide Removal Launchpad Projects report from Mission Innovation,¹ in which member countries submit data on demonstration projects that have been announced, are under construction or are in operation. The second source is a document from the Clean Energy Ministerial and Mission Innovation Ministerial Meeting² that summarizes policy, program and project developments across these initiatives, including CDR demonstration projects. The third source is The State of Energy Innovation report from the International Energy Agency.³

To categorize the status of the CDR demonstration projects, we align our tracking with Chapter 7 by using the International Energy Agency's CCUS tracker⁴ to categorize operational and under construction projects. We also use puro.earth registries⁵ to categorize operational projects. We supplement these tracking with press releases from companies associated with demonstration projects to gather information about the status of a project. For country and regional profiles of demonstration project funding, currency conversions were calculated using exchange rates in January 2026.

A3.2 Growth in the CDR start-up ecosystem

Data collection: Net Zero Insights

We use the Net Zero Insights (NZI) database⁶ to evaluate early-stage investments in CDR startups. NZI integrates automated data collection, direct company submissions and manual validation to track investments in climate-mitigating technologies (climate-tech). Almost all of the startups develop mitigation products or services, with a few startups focused on improving resilience of communities to climate change. NZI relies on publicly available information and is published in English, so it may miss some private investments or investments reported in other languages. Newer and smaller companies are harder to identify prior to fundraising or public announcements, so NZI may undercount recently founded companies.

NZI categorizes companies in a taxonomy of climate-tech solutions. We first identify 2,976 companies categorized in the (1) Greenhouse Gas Capture, Removal and Storage, (2) Carbon Markets and Offsets, and (3) Afforestation & Reforestation (AR) categories and constituent subcategories. We then categorize these according to the CDR methods descriptions in Chapter 1 (see below). We also download investor information for investors in these companies. Finally, NZI reports investments across all climate-tech companies in its database, which we present in Figure 3.3b.

The dataset of 2,976 companies identified from the categories above contains two relevant lists. The first list contains a unique ID within the NZI database, a description, tags and 67 other characteristics, including C-suite contact information, if available. The description is a short, 2-5 sentence statement about its activities. NZI also adds tags to each company, which include the categories and subcategories within their taxonomy. A separate list of investments contains 21 characteristics, including a unique funding round ID, the company ID, and funding round details such as deal type, date and amount. For our analysis, we aggregate the deal types into five simplified types (see Figure 3.3b).

The separate investor download also contains two relevant lists. The first list contains 29 investor characteristics, including a unique investor ID and investor type. For our analysis, we aggregate investor types into five simplified types (see Figure 3.3d). The second list contains 37 characteristics about investments made by these investors, across all climate-tech companies in NZI, including investor ID, funding round ID and company ID. Because this list contains all IDs to link investors and companies, we primarily use this list of investments for our analysis. However, this investor-perspective list of investments and the company-perspective list of investments report the same information.

NZI reports on investments in companies whose primary activity is the development of climate-tech solutions (typically startups, scale-ups, and small-to-medium enterprises). As

such, they exclude diversified incumbents whose CDR activity represents only a subset of broader operations. Where relevant, they may capture external investments made by these incumbents into CDR-focused companies, but do not systematically track or attribute their internal funding CDR projects. Two notable exceptions are for debt financing by established energy companies that report CDR activities: Stockholm Exergi and Northstar Clean Energy. Stockholm Exergi has raised debt to finance the construction of an 800,000 tonne CO₂ BECCS plant, so we include it in our analysis. Northstar Clean Energy mentions BECCS in its company description, but its only reported investment is for constructing a solar farm, so we remove it from our analysis.

Since NZI is largely sourced from public announcements, recent announcements may not yet be represented in the dataset. This is especially true for the number of startups founded. The measured decline in startups founded in 2024 and 2025 may be due to a data availability bias in recent years, since newer and smaller firms are inherently harder to track prior to fundraising or public announcements. For example, the number of startups published in the 2nd Edition of *The State of CDR* report indicates underreporting in the most recent three years of data: the number of startups reported for 2023 in the second edition is only 18% of the number of startups reported in this edition. Data for the second edition were collected at the beginning of 2024, and data for this edition were collected at the beginning of 2026.

Data collection: CDRjobs

For Box 3.4, job posting data were sourced from CDRjobs⁷, a platform that aggregates publicly available vacancies from CDR companies and CDR-enabling companies. CDRjobs employs a combination of methods, including web scraping of publicly available job listings and manual submissions by companies. For this report, we partnered with CDRjobs, which provided a dataset of 5,298 CDR jobs from 2024 to 2025 in Excel format, which we processed in Python to classify postings by method and skill type.

A rule-based multilingual text classification approach was applied, searching for weighted keywords and role cues across several languages. Particular emphasis was placed on sections of job descriptions beginning with recruitment lead-ins such as “we are seeking” or “you will”, as these typically describe the core function of the role. Each posting was assigned to standardized skill categories, including engineering, research and development, scientists, operations, technicians, finance and business development, marketing and sales, policy, legal, IT/digital, strategy, and administrative or human resources roles. For quality assurance, further cleaning was conducted by manually cross-checking job posting titles against existing discipline labels and adjusting as needed to match the job title. Short-term or temporary positions, such as internships, contracts, and part-time roles, were eliminated unless it was explicitly stated that the position could lead to a full-term contract. In total, 4,536 jobs remained.

Company categorization

We use a combination of automated key word searches and manual review to categorize the 2,976 companies from NZI.⁶ We develop a list of key words for each CDR method in Chapter 1 using tags for these companies in NZI (such as “SCS” for soil carbon sequestration or “DAC” for DACCS), along with phrases that unambiguously describe specific CDR methods (such as “BECCS”). For companies that engage in multiple types of CDR, we identify the most prevalent method mentioned in the description. We also use key words to search for both enabling and CDR-adjacent companies, both companies that contain CDR method-specific key words and those that do not. Enabling companies are software or service companies that support the CDR ecosystem without directly removing CO₂ from the atmosphere. If these companies specify which CDR method they support, we include that company in our main analysis. Adjacent CDR companies do not meet the definition of CDR in Chapter 1, but develop relevant carbon capture technology, such as point-source capture or utilization of captured carbon. We do not include these companies in our main analysis. Finally, we manually review all 2,976 companies to ensure correct categorization.

A3.3 Long-term company ambition

Data collection

We gathered data on company ambitions for carbon removal capacity between 2030 and 2050 using three sources: an industry survey of CDR companies, the Net Zero Insights database,⁶ and updates to the company ambition database from the 2nd Edition of *The State of CDR*.⁸ Company ambitions were included in the dataset if they included both a year and removal capacity in the ambition.

Industry survey

State of CDR authors partnered with cdr.fyi⁹ to send an industry-wide survey to CDR companies on current CDR and future ambition. Responses included in Chapter 3 were gathered between November 10, 2025, and January 20, 2026.

For data gathering, we used responses to the question:

If your company has publicly announced future CO₂ removal ambitions or goals, please include the values and the years associated with any such announcements here. These may be presented as specific cumulative levels of CO₂ removal to be achieved (e.g., 10 million tonnes of CO₂ from 2030-2050), or as an annual target capacity (e.g., 50,000 tonnes of CO₂ per year starting in 2030). Please also include units so that we can distinguish between annual (tonnes CO₂/yr) and cumulative (tonnes CO₂), and if cumulative, please also define start of period, i.e. 50,000 tonnes of CO₂ between 2030-2035. If you have goals across multiple years, please provide all here.

Example: 2023: 50,000 tonnes CO₂/yr; 2024: 60,000 tonnes CO₂/yr; 2025: 60,000 tonnes CO₂/yr

If the responses included a year and announced amount of removal capacity by that year, we included the data in the analysis.

Companies in NZI database

We also searched for targets for companies in the NZI Database.⁶ First, we filtered the dataset to include companies that received Series C or later-stage funding. We searched websites for each of these companies manually for references to a stated company removal ambition. Second, we searched the pitchlines of all companies in the database to include key terms that may indicate a company ambition. These terms were “*ton*”, “2030”, “2035”, “2040”, “2045” and “2050”.

Companies in The State of CDR 2nd Edition

We checked the websites of each company included in the 2nd Edition of *The State of CDR*⁸ to see if they still publicly stated a removal ambition and, if so, whether that ambition had changed.

Data description

Thirty-four companies responded to the survey and 86 companies were included in the analysis through the other two mechanisms, for a total of 120. It should be noted that some companies may have ambitions that have not been disclosed publicly while others may have announced ambitions only for the short term. Of these 120 companies, 32 either made public announcements or responded to the survey with an ambition that include both a year and capacity for the 2030–2050 period. We analysed 52 individual ambitions at the company level.

Cumulative announcements

For each company with an announced removal ambition, we created a time series between the year that the removal would start until 2050. We assume that each company will reach the target by the year in which the ambition is announced. We also assume that the company will annually remove that amount of CO₂ until another ambition is announced or until 2050.

We exclude any company ambition if it is not clearly a company-specific amount, but rather may be an industry-wide ambition. One company ambition is included as a point in the figure for display purposes but is not included in the cumulative total nor the cumulative line: the ambition is 10 GtCO₂ of removals by 2050. Because this ambition is not clearly specific to a single company and instead may be an industry target included on a company's website, we do not include it in a total to avoid double-counting.

We calculate the cumulative amount of CDR that would be operational each year by summing each time series.

A3.4 Upscaling comparisons

Data collection

We use global data on technology adoption from the Historical Adoption of Technologies (HATCH) dataset to visualize the growth pathway of each technology and to calculate compound annual growth rates for each technology.¹⁰

Curve fitting and growth rate calculation

In Figure 3.5a, we plot the fitted values from fitting a logistic curve onto the time series of each technology with global values in the HATCH dataset. If there are not global values, we sum all countries included in the HATCH dataset to aggregate to a proxy for a global value. We fit a logistic curve onto each time series with three free parameters using the `curve_fit` package in Python, which uses least-squares optimization and starting parameters to fit a logistic curve onto the time series. We also use data on the first year of commercialization for each technology from an expanded HATCH dataset and calculate the fitted values from the first year of commercialization until 25 years after the first year using the parameters from the logistic function fit. We also scale the values to the asymptote value that is extracted from the logistic fit function.

In Figure 3.5b, we calculate a compound annual growth rate for each global time series or the proxy for global time series (the sum of all countries included in HATCH dataset).

References

1. Mission Innovation. *Carbon Dioxide Removal (CDR) Launchpad Projects* <https://mission-innovation.net/wp-content/uploads/2024/10/CDR-Launchpad-Projects-Oct-2024.pdf> (2025).
2. Mission Innovation. *Developments with Carbon Management (CCUS and CDR) Programmes* https://www.cleanenergyministerial.org/content/uploads/2025/08/carbon-management-programmes_26aug2025.pdf (2025).
3. The State of Energy Innovation 2025 – Analysis. *IEA* <https://iea.blob.core.windows.net/assets/6ff289bd-5399-4625-9003-5218c2b-9deab/Thestateofenergyinnovation.pdf> (2025).
4. CCUS Projects Database – Data product. *IEA* <https://www.iea.org/data-and-statistics/data-product/ccus-projects-database>.
5. Puro.earth | Registry. *Puro Registry* <https://registry.puro.earth/retirements>.
6. Net Zero Insights. *Market Intelligence for the Net Zero Economy* <https://netzeroinsights.com/>.
7. CDRjobs | ALL jobs in carbon removal. *Cdrjobs* <https://www.cdrjobs.earth>.
8. Smith, S. *et al.* The state of carbon dioxide removal. (2024).
9. CDR.fyi – Carbon Removal Market Data, Leaderboards & Intelligence. <https://www.cdr.fyi/>.
10. Nemet, G., Greene, J., Zaiser, A. & Hammersmith, A. Historical Adoption of Technologies (HATCH) Dataset. Zenodo <https://doi.org/10.5281/zenodo.10231865> (2023).