



XPRIZE
CARBON
REMOVAL



MUSK FOUNDATION

Phase 2 Rules

V1.0 February 1, 2023

Foreword

These Rules are issued for Phase 2 of the XPRIZE Carbon Removal competition to supplement the [Competition Guidelines](#). While the Guidelines remain in full effect as the primary document governing the competition, at each round of the competition, Rules documents are published to provide necessary operational details specific to that round of the competition.

Phase 2 of the competition includes:

1. [Selection of Finalist Teams](#)
2. [Measurement & Verification of Finalist Teams](#)
3. [Selection of Grand Prize winners](#)

The aim of publishing these Rules is not to change any requirements of the competition but to provide details and clarity about how the final demonstration and testing phase of the competition will be administered leading to the award of the Grand Prize. Having said that, we have made a small number of important administrative changes worth noting:

What has changed:

1. **All Teams planning to compete for the Grand Prize are required to submit an “Intent to Compete” Form by September 7, 2023.** This form is outlined in [Appendix A](#) and will be available to complete in the Prize Operations Portal by July 11, 2023.
2. The Final Registration deadline has been updated to coincide with the Intent to Compete deadline on September 7, 2023 for operational planning reasons. This deadline was formerly December 1, 2023.
3. Additional clarity has been added to the calendar including several minor changes to submission dates in 2024 and 2025.

What has not changed:

1. The eligibility requirements, demonstration requirements, prize purse, prize structure, and overall scope of the competition have not changed.

What is new:

1. Detailed requirements for every submission through the end of the competition.
2. Details about the measurement, reporting, and verification program that will be used to assess finalist Teams.

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Eligibility

Phase 2 of the XPRIZE Carbon Removal is open to all Teams who meet the scope and eligibility requirements defined in the [Competition Guidelines](#), regardless of their participation or status in Phase 1 (Milestone Round) of the competition.

Phase 2 Competition Calendar

Please note the bold lines indicate changes or details not included in the original guidelines.

PHASE TWO: FULL DEMONSTRATION (YEARS 2-4, 2022-2025)

- | | |
|--|--|
| ● Intent to Compete Submission Portal Open | July 11, 2023 |
| ● Intent to Compete & Registration Deadline | September 7, 2023 |
| ● Finalist Application Submission Portal Open | October 4, 2023 |
| ● Finalist Application Deadline | February 1, 2024 |
| ● Finalist Judging and Selection | February - March 2024 |
| ● Public Announcement of Finalists | April 2024 |
| ● Final Demonstration Period | February 1, 2024 - January 31, 2025 |
| ● Finalist Measurement & Verification Site Visits | March 2024 - January 2025 |
| ● Grand Prize Submission Portal Open | September 1, 2024 |
| ● Grand Prize Submission Deadline | February 11, 2025 |
| ● Grand Prize Judging | February - March 2025 |
| ● Grand Prize Announcement | April 2025 |

All registrations and submissions are due at noon (12 PM), Pacific Standard Time, on the dates specified. XPRIZE reserves the right to extend these deadlines at their discretion.

1. Demonstration Requirements

To be eligible to win the Grand Prize, Teams must demonstrate their entire carbon dioxide removal solution end-to-end in the final year of competition. The demonstration requirements outlined here have previously been published in the [Competition Guidelines](#) and the Phase 1 Rules. They are repeated here with minor edits for clarity and emphasis:

1.1. Scope of Carbon Dioxide Removal Demonstration

The project must demonstrate all steps of carbon dioxide removal, from the point of capture through durable sequestration.

The demonstration project must capture CO₂ from the air or surface layer (i.e. epipelagic zone) of the ocean, such that the project will ultimately draw down CO₂ from the atmosphere on a net basis.

CO₂ may be sequestered as CO₂ (as in the case of some forms of geological sequestration) or it may be chemically converted into another substance as part of the sequestration strategy. Sequestration may be carried out at a separate site from the site of CO₂ capture (for systems that require separate capture and sequestration steps) provided that the same CO₂ molecules are captured and sequestered.

Only removals that will not happen on their own (that is, without the interventions demonstrated by the Team) may be considered.

Teams may employ the help of partners (other individuals or organizations) to aid in any aspect of the Carbon Dioxide Removal project (for example, a CO₂ capture partner, or sequestration partner), provided those partners supply the technical and project documentation required by the XPRIZE Carbon Removal submission & verification processes, and submit to verification site visits upon request.

Demonstration projects are not limited to a single site, provided they meet the following requirements:

- The Team can explain clearly why a demonstration in a single physical location is not feasible;
- Each physical location represents an instance of the same CO₂ removal solution (not a collection of distinct CO₂ removal solutions);
- The Team presents a feasible plan for validation of their performance across multiple locations.
- The Team can make a case that the scalability of the solution (through MT and GT scale) is not hindered by the distributed nature of the solution.

- The solution can be adequately verified in a single site visit.
- The Team can provide evidence that a sufficient number of solutions are operating to satisfy the required scale of removal (1000 tonnes of removal in the final year of the competition).

1.2. Scale of Carbon Dioxide Removal Project

The target scale for XPRIZE Carbon Removal is at least 1000 tonnes/year of CO₂ durably sequestered. Teams must durably sequester at least 1000 tonnes of CO₂ in the final year of competition (February 1, 2024 to January 31, 2025).

Tonnes/year refers to the rate of CO₂ removal, averaged over time, measured in metric tonnes per year, after deducting all emissions associated with the process and any expected re-emissions within 100 years (in other words, *net removal*).

Net removal can be calculated using the following formula:

$$Removed_{net} = Removed_{gross} \times (1 - Reemission_{100}) - Emissions$$

Where:

Removed_{net} is the Net annual CO₂ removal rate (tonnes/year)

Removed_{gross} is the total mass rate of CO₂ removed from the air or ocean (tonnes/year)

Reemission₁₀₀ is the fraction of sequestered CO₂ that can be expected to re-emit within 100 years (%)

Emissions is the annual rate of emissions associated with the carbon dioxide removal project (tonnesCO_{2e}/year), not including re-emission of sequestered CO₂.

1.3. Durability of Sequestered CO₂

The durability threshold for the competition is 100 years. This means that to be considered removed, CO₂ must be sequestered (on a net basis) over at least 100 years. Only removals that will not happen on their own without intervention may be considered. **Solutions which are inherently less durable than 100 years (in particular, certain nature-based solutions) are still eligible** so long as they are paired with management practices that ensure that, on net, the claimed quantity of CO₂ is removed and sequestered for at least 100 years. Similarly, solutions that offer inherent durability in excess of 100 years, without active intervention (e.g.

some forms of mineralization or geologic sequestration) are also fully in scope.¹

Durability can be achieved in one of two ways. First, the carbon dioxide removal solution may generate a form of carbon that is well known to have a lifetime much longer than 100 years (e.g. calcium carbonate, as just one example). Proper storage or custody of that form of carbon can then ensure durability over 100 years. Second, the carbon dioxide removal solution may generate a form of carbon that is not itself stable over 100 years (e.g. a protein in a living plant), however with active or passive management of the solution, ongoing repetition of the removal process, and/or monitoring, the overall system can ensure that on net, CO₂ remains sequestered over 100 years (e.g. a healthy ecosystem or actively managed ecosystem, as just one example). **It is the responsibility of each Team to provide the judges with confidence that their carbon dioxide removal solution will result in ongoing additional removals that are durable for at least 100 years.**

Each Team must establish the durability of their sequestered CO₂. This may include references to (this list is not exhaustive):

- The chemical stability of the sequestered CO₂;
- The Team's strategy for managing the sequestered CO₂ to minimize re-emission or otherwise capture CO₂ in sufficient quantities that a net CO₂ flux of 1000 tonnes per year can be expected to remain sequestered for at least 100 years;
- Experimental work conducted by the Team supporting their claims of durability;
- Other standards which establish the durability of the proposed method of CO₂ sequestration.

CO₂ is considered durably sequestered if it can be stored in a stable and safe manner for at least 100 years. In the event that a fraction of the sequestered CO₂ is likely to be re-emitted within 100 years, that CO₂ should not be considered sequestered for the purpose of calculating the system scale, and should be accounted for as an emission source in the emissions assessment section of the Sustainability Analysis.

¹ See Leitch & Griscom. (December 6, 2022) [Can A Natural Climate Solution Win The XPRIZE Carbon Removal? www.xprize.org/carbonremoval](https://www.xprize.org/carbonremoval)

2. Selection of Finalist Teams

The XPRIZE Carbon Removal judges will select up to 20 Finalist Teams to participate in XPRIZE’s Measurement Reporting and Verification program. This section describes the requirements and process that will be used to select Finalist Teams:

2.1. Registration

All Teams must register for the competition by the Final Registration deadline. **As noted in the calendar above, the Final Registration deadline has been changed to September 7, 2023.** The registration process includes signing the XPRIZE [Competitor Agreement](#) and paying the registration fee (US\$250).

Teams who registered for Phase 1 of the competition do not need to re-register, however, **we urge every Team to log in to their [POP profile](#) and check to ensure their registration details and contact information are up to date.**

2.2. Intent to Compete

All Teams who wish to apply for a finalist position must submit to XPRIZE an “Intent to Compete” form by September 7, 2023. Submissions will be collected on the XPRIZE [Prize Operations Portal \(POP\)](#). Please refer to [Appendix A](#) for a tentative outline of that submission form. The final template will be made available by the date specified in the Phase 2 Competition Calendar above.

2.3. Finalist Application Submission

Teams who wish to apply for the Finals must submit a Finalist Application Submission by the February 1, 2024 deadline. Please refer to [Appendix B](#) for a tentative outline of that submission form. This submission will collect:

- Technical details about the Team’s demonstration;
- Self-reported sustainability assessment;
- Self-reported cost assessment.

Submissions will be collected on the XPRIZE [Prize Operations Portal \(POP\)](#). The final submission template will be made available by the date specified in the Phase 2 Competition Calendar above.

2.4. Selection of Finalist Teams

The judging panel will select Finalist Teams based on their assessment of each Team’s Finalist Application.

Up to twenty (20) Finalist Teams may be named, as well as “runners up” (at the

discretion of the judging panel). Finalists will be subject to the Measurement & Verification processes outlined in [Section 3](#). The judging panel may promote runners up Teams to Finalist Teams at any point in the competition.

2.5. Evaluation Criteria

The following chart has been adapted from the [Competition Guidelines](#) to suit the needs of the Finalist Selection process. The high-level Evaluation Criteria outlined in the guidelines remain unchanged.

REQUIREMENT	CRITERIA
<p>Operational Requirements</p>	<p>The judges must be satisfied that the Team is capable of removing and durably sequestering at least 1000 net metric tonnes of CO₂ during the 12-month demonstration period. They will consider the status and scale of current operations, quality of engineering & instrumentation, and proposed operational schedule in making this determination.</p> <p>Note that measured performance data from a Team’s demonstration is the strongest indicator of potential for success in the Finals. Although not a strict requirement at the time of submission, submission of performance data in a Team’s Finalist Application can be considered a competitive advantage.</p> <p>In the event that there are not more than 20 applicants who meet or exceed the 1000 tonne/year threshold, the judges may pass Teams who plan to operate at a smaller scale.</p>
<p>Sustainably Scaleable</p>	<p>The claimed scale of operations (in terms of net removals) must be supported by the Team’s Carbon Assessment/LCA and Durability Assessment.</p> <p>Teams must explicitly address the non-CO₂ environmental impacts of the proposed solution, including energy, land, water, and other natural resource needs, benefits, positive or negative impacts on biodiversity and other ecosystem services, and constraints of their solutions.</p> <p>Teams must discuss their plans for addressing and achieving broad social license and acceptance, equity, and environmental</p>

justice. XPRIZE considers these attributes to be important goals in and of themselves, and also significant barriers to deployment at low cost and at Gigatonne scales if ignored.

**Fully Considered
Cost**

Teams who meet or exceed the Operational and Sustainable Scaling requirements will be ranked by cost in order to select the finalist Teams and runners up. Judges will take into consideration both the quality of the cost analysis and level of uncertainty in the cost calculation when determining the final ranking of Teams.

2.6. Safety & Regulatory Compliance

The judging panel may decline to name a Team as a finalist if there are concerns that Team operations may be unsafe, environmentally unsound, or out of compliance with existing laws and regulations.

3. Measurement & Verification of Finalist Teams

Finalist Teams must participate in XPRIZE's Measurement & Verification (MRV) process in order to be considered for a grand prize. MRV will be completed by 3rd party contractors hired and paid for by XPRIZE during the verification period indicated in the competition schedule. MRV will consist of three major activities:

- Performance Verification;
- Sustainability Analysis;
- Cost Analysis.

3.1. Performance Verification

This activity aims to confirm performance attributes of the Team's demonstration and verify that the data used to perform the Sustainability Analysis and Cost Analysis is accurate. Tasks related to on-site verification may be scheduled any time throughout the final twelve-month demonstration period, but XPRIZE will make every effort to ensure verification is as minimally invasive as possible.

Performance Verification will normally include:

- Analysis of engineering and/or performance data related to the demonstration;
- Development of a Team-specific verification plan;
- A site visit, estimated to last 3 days;
- Remote monitoring of key data streams over several months;
- Regular reporting from the demonstration Team;
- Collection and analysis of physical samples, as needed.

As soon as possible after each finalist Team is named by the Judging Panel, XPRIZE will assign a Verification Contractor to develop a verification plan for that Team. Verification Contractors will develop a Team-specific verification plan based on the information contained in their submission. They may seek additional details from each Team about their demonstration as needed.

Draft verification plans will be distributed to XPRIZE and the finalist Team for comment. Verification contractors will make every effort to incorporate comments and requests from finalist Teams. XPRIZE may seek additional consultation or advice from appropriate parties (judges, advisors, or other contractors) as needed to resolve conflicts and ensure that the verification plans meet the competition requirements. XPRIZE will sign off on the final verification plan.

Preliminary or interim reports may be produced by verification contractors to communicate progress against each Team’s verification plan. These reports may be produced on a regular basis or after key milestones. Once verification activities have been completed, a final report will be produced.

See [Appendix D](#) for more details.

3.2. Sustainability Analysis

Sustainability Analysis aims to confirm:

- Scale demonstrated during the competition;
- Scalable to gigatonne scale;
- Durable CO₂ sequestration;
- Net negative performance;
- Environmental sustainability;
- Social license & environmental justice.

Contractors hired by XPRIZE will complete an initial analysis using the data provided by Teams in their Finalist Application. If additional details are required, contractors will seek those details from the Teams. The initial analysis will be distributed to Teams for comment and revision if necessary. Once verified performance data is available, the analysis will be revised to incorporate that data and a final report will be produced.

See [Appendix E](#) for more details.

3.3. Cost Analysis

In the finals, each Team’s fully considered cost will be calculated via a Techno-Economic Analysis. This analysis will include:

- The expected performance of the solution being demonstrated at a megatonne-scale (i.e. 1 million tonnes per year);
- Full cost of CO₂;
- Cost of Risk and Externalities;
- Revenue and Value.

Contractors hired by XPRIZE will complete an initial analysis using the data provided by Teams in their Finalist Application. If additional details are required, contractors will seek those details from the Teams. The initial analysis will be distributed to Teams for comment and revision if necessary. Once verified performance data is available, the analysis will be revised to incorporate that data and a final report will be produced.

See [Appendix F](#) for more details.

3.4. Roles and Responsibilities

XPRIZE will:

- Hire and compensate verification contractors;
- Assign verification contractors to work with each Team;
- Establish the verification requirements, approve verification plans, and approve any changes to the verification plans;
- Manage the scheduling of verification activities;
- Attend site visits as observers;
- Manage any conflicts that may arise between verification contractors and finalist Teams.

Contractors will:

- Ensure that staff assigned to each activity have the sufficient professional competence to complete the contracted verification activities;
- Ensure that staff assigned to each verification activity are free of real or perceived conflicts of interest;
- Seek any required information from Teams to facilitate planning and or execution of verification plans;
- Cooperate with Teams to facilitate the verification process;
- Draft Team-specific verification plans;
- Complete all contracted verification activities;
- Keep confidential all Team IP;
- Produce verification reports consistent with XPRIZE requirements.

Finalist Teams will:

- Provide information (including plans, data, schematics, specifications, etc.) requested by XPRIZE or Verification Contractors in a timely fashion;
- Facilitate access to their demonstration facility(s);
- Coordinate with the verification contractors as needed to ensure verification activities can be completed safely and effectively;
- Make data and/or instrumentation available to verifiers as specified in their verification plan.

3.5. Compliance with Methodologies & Other Best Practices

Compliance with existing methodologies is not a requirement of the competition, however, Teams should make every effort to adhere to recognized best practices wherever possible. Contractors will align verification plans with existing

methodologies where possible. Should no suitable formal methodologies exist, verification plans will draw upon existing best practices and first principles.

3.6. Quality

Each verification report will discuss the quality of data provided by Teams and, where possible, calculate uncertainty related to each major performance metric. Verifiers may make recommendations to Teams with respect to instrumentation or data collection methods to improve confidence in data, but nevertheless, it is each Team's responsibility to provide XPRIZE with high-quality data meeting or exceeding best practices for that Team's CDR solution.

3.7. Safety

Operational and environmental health and safety are fundamental considerations in this competition. Teams are responsible for operating safely and in compliance with local, regional, and national occupational health, safety, and environmental regulations relevant to their demonstrations.

Teams are responsible for ensuring the safety of all XPRIZE personnel while visiting Team demonstration locations. Teams must provide verifiers with any orientations or safety training required by their demonstration sites. Teams must participate in safety briefings and hazard assessments conducted by verifiers before they commence their work on-site.

XPRIZE staff, judges, and/or third-party measurement and verification personnel reserve the right to refuse to complete verification activities on Team sites they deem to be unsafe, or until such time as the testing at the Team site can be rendered safe. XPRIZE will make final determinations on safe and acceptable operating conditions for competition operations.

3.8. Disqualification

Finalist Teams are expected to cooperate with XPRIZE to facilitate finalist verification processes. This includes:

- Timely responses to requests for information;
- Cooperation with scheduling, logistical planning, and facilitation of site visits;
- Provision of requested technical details and performance data;
- Addressing concerns regarding safety.

XPRIZE will make every effort to cooperate with Finalist Teams, communicate proactively, and accommodate each finalist Team's specific circumstances.

However, XPRIZE reserves the right to disqualify Teams for lack of cooperation during this process. See the [Competitor Agreement](#) section 3.5.

3.9. Media

Finalist Teams will be expected to participate in media and marketing activities related to the prize including the filming of site visits. XPRIZE will work with each Team to ensure that media and marketing activities do not compromise trade secrets or other confidential information. Please refer to the [Competitor Agreement](#) (in particular, the Media Rights Agreement and Confidentiality provisions).

3.10. Intellectual Property & Data Confidentiality

Please refer to the [Competitor Agreement](#) (in particular, sections 9-12) for details about XPRIZE's treatment of intellectual property and confidential information. In summary:

- Each Team must own, or have a valid license covering their use of, all intellectual property and equipment associated with their submissions and demonstration.
- Teams retain ownership of any intellectual property they develop as part of their competition entry.
- All materials disclosed to XPRIZE in the team's submissions are protected by confidentiality agreements.
- All competition personnel (including XPRIZE staff, judges, and contractors) with access to Team confidential information are bound to confidentiality provisions. Nevertheless, access to Team confidential information will be granted on a strict need-to-know basis.

3.11. Final Verification Reports

The final reports produced by contractors under each of the three major verification activities (Performance verification, Sustainability analysis, and Cost analysis) will be provided to each team at least two weeks in advance of the Grand Prize Submission deadline so that teams have an opportunity to review and provide commentary as part of their Grand Prize Submission. After the Submission Deadline, XPRIZE will make the final reports available to the judges for review.

4. Selection of Grand Prize Winners

Finalist Teams who complete the Measurement & Verification process are eligible for Grand Prize Awards. A Grand Prize Submission will give Teams the opportunity to make their final case to the Judging Panel.

4.1. Grand Prize Submission

Finalist Teams will be invited to submit to XPRIZE a “Grand Prize Submission” by the Grand Prize Submission deadline (February 2025). This submission will:

- Collect up-to-date administrative details
- Give Teams the opportunity to provide a final summary of their performance over the demonstration period.
- Give Teams the opportunity to comment on their verification reports

Materials reviewed by the judging panel will include:

- Grand prize submission provided by Team
- Verification reports (previously shared with Teams) from XPRIZE.

Submissions will be collected on the XPRIZE [Prize Operations Portal \(POP\)](#). Please refer to [Appendix C](#) for a tentative outline of that submission form. The final template will be made available by the date specified in the Phase 2 Competition Calendar above.

4.2. Evaluation Criteria

The Judging Panel will use the Evaluation Criteria established in the Guidelines to award the grand prize winner and runners up. Please see the “Evaluation Criteria” section of the [Competition Guidelines](#) for complete details.

4.3. Award Payment

Awards will be paid to the legal entity specified on the winning Team’s Competitor Agreement. Awards will be paid as promptly as possible following the announcement of the winners. Payments will be contingent on confirmation that the winning Team has satisfied all of the conditions outlined in the [Competitor Agreement](#).

Appendix A. Intent to Compete Outline

The 'Intent to Compete' is a mandatory questionnaire that must be filled out by all Teams who intend to compete for the Grand Prize. This questionnaire is designed to aid XPRIZE in planning the final round of the competition, **and will not be reviewed by the judges or used in the evaluation of Teams.**

Teams who do not submit the Intent to Compete form by the deadline will not be eligible to be named Finalists, or eligible for the Grand Prize.

Information submitted in this questionnaire may be published by XPRIZE to promote the competition, but all data will be aggregated and anonymized.

Please be as honest as possible. We are using this information for planning purposes and it will help us a great deal if you are honest and candid with your responses. Again, please note that your answers will not be used in any selection processes.

This questionnaire must be filled out on the XPRIZE [Prize Operations Portal \(POP\)](#). The questions listed below may vary from those in POP:

1. Project Details:
 - a. What is your primary solution track?
 - b. What is your secondary solution track?
 - c. Updated project description. (Short answer)
 - d. Does your demonstration follow any published standards or methodologies?
 - i. Please list all applicable (Short answer)

2. Demonstration Location:
 - a. Has your demonstration location been finalized?
 - b. If not, when do you expect to finalize this? (Short answer)
 - c. Where will your demonstration take place? If your demonstration spans multiple sites, please identify a 'primary' site.
 - i. Location name/description (Short answer)
 - ii. Country (Short answer)
 - iii. City (or closest city)? (Short answer)
 - d. Have you secured the necessary land rights & permits to operate?
 - i. If not, when do you expect to receive all necessary permits to operate? (100 words)
 - e. Does the demonstration span multiple locations?

- f. If there is more than one location, please describe. (Short answer)
3. Operational Details:
- a. Do you have custody of your demonstration site (i.e. have you moved in, started construction, etc)?
 - b. Have you started operating on the site you intend to demonstrate?
 - c. Have you started operating elsewhere?
 - i. If you are operating somewhere other than your final demonstration location, give us a sense of where you are at today and your plan to get to site. (Short answer)
 - d. At what scale are you operating today (tonnes/year)? (Short answer)
 - e. Does that include both capture and sequestration? (Short answer)
 - i. How much CO₂ have you captured to date? (Short answer)
 - ii. How much CO₂ have you sequestered to date? (Short answer)
4. Demonstration Planning:
- a. How much CO₂ do you intend to capture and sequester during the demonstration period (February 1, 2024 - January 31, 2025)? (Short answer)
 - i. When do you expect to begin operations at your “full demonstration scale”? (Short answer)
 - ii. What months of the year are you planning to operate during the demonstration period?
 - b. Is your demonstration operation seasonal (as opposed to operating year-round)?
 - i. If yes, please explain (Short answer)
 - c. How is the CO₂ captured?
 - i. How do you measure the rate of capture? (Short answer)
 - ii. What instruments are used? (Short answer)
 - iii. How is your CO₂ capture data collected? (Short answer)
 - iv. How is the CO₂ sequestered? (Short answer)
 - v. How do you verify the CO₂ remains sequestered? (Short answer)
 - vi. What instruments or measurements are taken? (Short answer)
 - vii. How is your CO₂ capture data collected? (Short answer)
5. Barriers
- a. What are the most significant issues or risks for your Team that may prevent a successful demonstration? (Short answer)
 - b. Please rate on a scale of 0-5 the risks and barriers that may compromise your ability to execute your XPRIZE demonstration (i.e. capture & sequester 1000 tonnes of CO₂ in the final year of the competition): (0 = no risk, 5 = acute risk)
 - i. Funding

- ii. Land rights
- iii. Permits
- iv. Construction schedule
- v. Supply chain
- vi. Availability of labor
- vii. Availability of feedstocks
- viii. Availability of energy
- ix. COVID pandemic
- x. Technology concerns

Appendix B. Finalist Application Submission Outline

What follows is a description of the questions and other documentation that will constitute the Finalist Application submission. This questionnaire must be filled out on the XPRIZE [Prize Operations Portal \(POP\)](#). The exact questions listed, word counts, etc. may vary from those in POP:

Operational Requirements	Type	Purpose
Video(s) of the demonstration in operation	Upload	Provide the judges with a short (~5 minutes) walk-through of your demonstration to show that it exists and to provide evidence of your current operational status.
Process Flow Diagram	Upload	Provide the judges with a technical overview of the demonstrated solution.
Process description	Long answer	Provide the judges with a high-level understanding of the process.
Operational Status (Summary)	Short answer form	This short questionnaire will summarize: <ul style="list-style-type: none"> - Demonstration Location - Date of Operations (or expected operations) - Quantity of CO₂ captured to date - Quantity of CO₂ sequestered to date - Other high level details
Operational Status (Detailed)	Worksheet	For each major piece of equipment and/or process included in the demonstration, provide: <ul style="list-style-type: none"> - Descriptions & operational status - Photo - Drawing or schematic - Performance data (table and/or graph)
Demonstration Scale	Long answer	Describe how you will achieve the competition requirement of sequestering >1000 tons in the final year of competition. Explain start dates, end dates, and rate of operation over the final year.
Letter of Reference	Worksheet	This short (approx. 2 page) questionnaire is to be filled out by a qualified and independent reviewer describing the status of construction and/or operations of the demonstration at the time of submission to serve as a letter of reference for your progress to date.
Sustainability Requirements	Type	Purpose
Describe the GT scenario	Long answer	Describe to the judges how you anticipate the demonstrated CDR solution will scale to Gigatonne levels (globally)

Sustainability Worksheet	Worksheet	Quantify and describe the impacts related to each of the following metrics that can be expected as your solution approaches Gigatonne scale (globally), and describe how you propose to manage or mitigate those impacts: <ul style="list-style-type: none"> - Feedstocks - Waste Streams - Land - Water - Energy - Environmental Impacts - Social Impacts
Description of Durability	Long answer	Summarize: <ul style="list-style-type: none"> - how the CO₂ is sequestered - how your Team assures durability of your sequestered CO₂
Durability Worksheet	Worksheet	Establish your Team's understanding of the re-emission risks and pathways and risks associated with the CDR solution by describing: <ul style="list-style-type: none"> - the mechanisms by which sequestered CO₂ can be expected to re-emit, and on what time scale - the pathways that may result in unintentional re-emission - literature or experimental work to support the claimed rate of re-emission - calculations behind any buffer pools or other strategies used to achieve an operational scale of 1000 tonnes/year, accounting for expected re-emission within 100 years.
Emissions Assessment	Worksheet	Establish that the demonstration removes at least 1000 tonnes/year on net, and data supporting other factors relating to the sustainability of the demonstration.
Environmental Justice	Worksheet	Teams must discuss their plans for addressing and achieving broad social license and acceptance, equity, and environmental justice.
Cost	Type	Purpose
Description of Megatonne Project	Long answer	Describe how the solution may achieve a megatonne commercial scale
Process Flow Diagram (Megatonne Scenario)	Upload	A full, complete process flow diagram is required, showing all components, all streams, and all mass and energy flows/requirements

Cost Worksheet	Worksheet	Establish your solution's Cost/tonne, for ranking purposes. Allow judges to assess the Team's ability to carry out a reasonable estimation of cost.
Verification Planning	Type	Purpose
Verification Planning Questionnaire	Short answer form	Specify: <ul style="list-style-type: none"> - Location(s) of demonstration - Dates of operation during 2024 - Ideal dates for verification - Flag dates when verification could NOT be accommodated - Access requirements, restrictions, or required training to access the sites - Flag major challenges to verification (due to access, or measurement precision, etc)

Appendix C. Grand Prize Submission Outline

What follows is a description of the questions that will constitute the Grand Prize submission.

This questionnaire must be filled out on the XPRIZE [Prize Operations Portal \(POP\)](#). The exact questions listed, word counts, etc. may vary from those in POP:

Operational Requirements	Type	Purpose
Verification Summary (provided by Verification contractor)	Short answer Form	Does the demonstration establish: - 1000 tonnes/year scale - Capture CO ₂ from the air/ocean - Durability of sequestered CO ₂ - Support the conclusions of the LCA and TEA?
Verification Report (provided by Verification contractor)	Report	Expand on the above - Uncertainty on primary performance parameters
Progress since verification	Long answer	Teams are given the opportunity to review and respond to the Verification report, and describe any progress made since verification.
Final Performance Dataset	Worksheet & Uploads	Upload a summary of the Team's performance over the full demonstration period.
Sustainability Requirements	Type	Purpose
Sustainability Summary (provided by Verification contractor)	Short answer form	CO ₂ Footprint Uncertainty
Sustainability Analysis (provided by Verification contractor)	Report	Establish the net CO ₂ footprint of the demonstration, in consideration of the solution's cradle-grave Establish Sustainability metrics
Sustainability Response	Long answer	Teams are given the opportunity to review and respond to the Verification report and describe any disagreements, grievances, or progress since verification.
Gigatonne Scale	Long answer	Teams are given the opportunity to finally make the case that their solution can scale sustainably to a gigatonne and beyond
Cost	Type	Purpose

Cost Summary (provided by Verification contractor)	Short answer form	Cost per tonne Uncertainty
Cost Analysis (provided by Verification contractor)	Report	Establish the "fully considered cost per tonne" at a projected megatonne scale of operations. Discuss risks, externalities, and opportunities for value creation.
Cost Response	Long answer	Teams are given the opportunity to review and respond to the Verification report and describe any disagreements, grievances, or progress since verification.

Appendix D. Performance Verification

The performance verification requirements are designed to give the judging panel confidence that Finalist Teams have met the “Operational Requirements” of the competition. These are (see [Competition Guidelines](#) for more detail):

- Operate a full carbon dioxide removal project (or projects) at a combined scale of at least 1000 tonnes of CO₂ removed per year. Demonstrations must include:
 - Removal of CO₂ from air or ocean;
 - All steps in the carbon dioxide removal process;
 - Durable sequestration of CO₂, including any required monitoring & management of the CO₂ store.
- Remove 1000 cumulative tons of CO₂ in the final year of competition.
- Demonstrate the solution’s performance with adequate precision, meeting or exceeding current best practices.

The requirements for this analysis draw from several technology verification methodologies and practices², as well as basic scientific and engineering practices, and will be carried out by qualified independent professionals. Verification results will inform the judging process, so high-quality data and transparency about uncertainty are required.

1. Assessment Process:

The full assessment will follow the following steps:

- a. Teams will submit technical details about their intended demonstration in their Finalist Application;
- b. Judges will select Finalist Teams using the initial submission;
- c. Independent contractors hired by XPRIZE will evaluate the initial submissions from the Finalists, identify the key performance claims made by each Team, and develop a verification plan for each finalist Team.

² For more information please refer to the following:

ISO 14034. (2016). *Environmental management-Environmental technology verification (ETV)* . ISO.

Hansen, T., McCabe, K., Chatterton, B., & Leitch, M. (2021). *Integrating the ISO 14034 standard as a platform for carbon capture and utilization technology performance evaluation*. *Clean Energy*, 5(4), 600–610. <https://doi.org/10.1093/ce/zkab033>

Gold Standard. (2022). *Site Visit and Remote Audit Requirements and Procedures*.

Microsoft. (2021). *Microsoft carbon removal: Lessons from an early corporate purchase*. Microsoft

- d. Each finalist Team will be given an opportunity to review and comment on their verification plan before the plan is finalized.
 - e. Once the verification plan is finalized, verification contractors will complete all of the activities specified in the verification plan, with the cooperation of the finalist Team, during the competition demonstration period.
 - f. By the end of the competition demonstration period, contractors will produce a final report summarizing their findings.
2. Scope of Assessment:
- a. Identify key performance claims provided by the demonstration Team:
 - i. Means of carbon dioxide removal and its method of durable removal;
 - ii. Required process steps and operations to achieve carbon dioxide removal;
 - iii. Data and performance metrics most critical to the overall performance of the system (ie. efficiency, rates of consumption/emission, composition of feedstocks, etc.);
 - iv. Data and performance metrics most critical to the Sustainability and Cost claims;
 - v. Activities and processes related to quality assurance and mitigation of social and environmental impacts;
 - vi. Attributes related to critical feedstocks, waste streams, and associated supply chains.
 - b. Recommend scope and activities related to each of the following verification tactics:
 - i. On-site technical audit (to verify, for example, instrumentation, processes, data handling, etc.);
 - ii. Regular data reporting from the CDR demonstration Team;
 - iii. Sample collection & analysis;
 - iv. Independent sensors or remote data acquisition;
 - v. Other data analysis and/or observations, as needed, to verify the demonstration Team's performance claims.
 - c. Reporting on each key competition metric:
 - i. Source of CO₂;
 - ii. System scale/rate of operation;
 - iii. Cumulative CO₂ removed;
 - iv. Durability of sequestered CO₂;
 - v. Sustainability metrics (energy, land, water, waste, etc).
 - d. Assess operational impacts, as they relate to the following:
 - i. Energy use;
 - ii. Land use and water area use;
 - iii. Process water use;
 - iv. Waste & Wastewater stream management;

- v. Feedstocks (where applicable) and related feedbacks;
 - vi. Biodiversity / Ecosystem function;
 - vii. Co-products & by-products;
 - viii. Social & economic impacts.
- e. Reference and align with published standards, protocols, and methodologies where possible.
 - f. Quantify uncertainty ranges for all applicable indicators, identifying the parameters whose uncertainty has the most significant impact on final indicators. Where quantification is not possible, other indicators of quality may be discussed.
 - g. Assess sensitivity to identify the parameters to which the final indicators are the most sensitive.
 - h. Discuss challenges faced when conducting the assessment and possible data gaps.
3. Verification Requirements:
- At a minimum, verification activities must consider the following:
- a. On-site technical audit:
 - i. Verify removal of CO₂ from air or ocean.
 - ii. Document that the observed process is operating at a steady state (or otherwise normal operating conditions);
 - iii. Ensure that the demonstration includes all steps in the removal process and that all input and outputs of the demonstrated component(s) are accounted for;
 - iv. Ensure data collected during observation is representative of data submitted;
 - v. Ensure measurements, analytical methods, or other data collection methods are adequate and properly implemented;
 - vi. Verify rate of removal and cumulative net tonnes of CO₂ removed;
 - vii. Assess data quality with respect to instrumentation, calibration, qualification of personnel, and other quality protocols;
 - viii. Identify and quantify source(s) of uncertainty;
 - ix. Assess/verify leakage points;
 - x. Assess/verify significant liabilities and risk factors related to operations.
 - xi. Assess/verify durability of sequestered CO₂;
 - b. Regular data reporting from the CDR demonstration Team:
 - i. As appropriate, collect summary data at regular intervals over the demonstration period.
 - ii. Documentation of disruptions to the demonstration (i.e. planned or unplanned downtime due to equipment failure, maintenance, weather events, etc)

- c. Sample collection & analysis:
 - i. Composition or quality of critical feedstocks or waste streams;
 - ii. Attributes related to assuring the durability of the sequestered CO₂;
 - iii. Confirmation of the accuracy of instrumentation;
 - iv. Verification of routine sample collection & analysis performed by the Team.
- d. Independent sensors or remote data acquisition:
 - i. Allow for independent observation of key performance indicators over the demonstration period;
- e. Review performance data collected during the observation period to ensure that:
 - i. The performance claims are supported by the observed process;
 - ii. Calculations are performed correctly;
 - iii. Uncertainty is properly reported and propagated through the top-level performance claims.

Appendix E. Sustainability Analysis

The objective of the Sustainability Analysis is to provide a methodical verification of each Finalist Team's performance claims, and independent calculation of key indicators, related to the "Sustainable Scalability" requirements of the competition. These are (see [Competition Guidelines](#) for more detail):

- Scale demonstrated during the competition;
- Scalable to gigatonne scale;
- Durable CO₂ sequestration;
- Net negative performance;
- Environmental sustainability;
- Social license & environmental justice.

The requirements for this analysis draw upon several methodologies including life cycle assessment (LCA), impact assessment, greenhouse gas accounting, environmental justice, and approaches outlined in literature related to carbon dioxide removal scalability assessment.³ Aspects of these multiple approaches are featured to enable insight into multiple dimensions of sustainability. The assessment will also inform the verification plans.

1. Assessment Process:

The full assessment will be guided by the following process:

- a. Teams will submit sustainability details as part of their Finalist Application;
- b. Judges will select Finalist Teams using the initial submission;
- c. Independent contractors hired by XPRIZE will evaluate the initial submissions from the Finalists. The evaluation will inform verification plans for the demonstration

³ For more information please refer to the following:

Langhorst, T., McCord, S., Zimmermann, et. al (2022). *Techno-Economic Assessment & Life-Cycle Assessment Guidelines for CO₂ Utilization (Version 2.0)*. Global CO₂ Initiative, University of Michigan. <https://dx.doi.org/10.7302/4190>

ISO 14040. (2020). *Environmental Management - Life cycle assessment - Principles and framework*

ISO 14044. (2020). *Environmental Management - Life cycle assessment - Requirements and guidelines*

European Commission - Joint Research Centre - Institute for Environment and Sustainability. (2010). *International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance*. EUR 24708 EN. Luxembourg. Publications Office of the European Union

T. J. Skone, M. Mutchek, M. Krynock, S. Moni, S. Rai, J. Chou, D. Carlson, M. Jamieson, E. Dale, G. Cooney, and A. Kumar. (2022). *Carbon Dioxide Utilization Life Cycle Analysis Guidance for the U.S. DOE Office of Fossil Energy and Carbon Management Version 2.0*. National Energy Technology Laboratory, Pittsburgh.

projects, and flag any additional information or data that may be needed to complete the Assessment;

- d. Additional analysis and modeling will be completed as necessary to compute the required indicators and assess impacts;
 - e. Once verified data is available, the analysis will be finalized;
 - f. By the end of the competition demonstration period, contractors will produce a final report summarizing their findings.
2. Scope of Assessment includes:
- a. Calculation of indicators defined below.
 - b. A functional unit/reference flow of one metric tonne of carbon dioxide removed from the atmosphere/ocean and durably sequestered.
 - c. Cradle-to-grave impacts associated with the system, including as much of the supply chain as possible and durable (≥ 100 -year) sequestration of the captured CO₂.
 - d. Discussion of mitigation plans proposed by the team.
 - e. Quantification of uncertainty ranges for all applicable indicators, identifying the parameters whose uncertainty has the most significant impact on final indicators. Where quantification is not possible, other indicators of quality may be discussed.
 - f. Assessment of sensitivity to identify the parameters to which the final indicators are the most sensitive.
 - g. Discussion of challenges faced when conducting the assessment and possible data gaps.
3. Inventory Data Requirements:
- a. Inventory data must be provided with reference to a complete and detailed Process Flow Diagram, associated stream tables, and mass & energy balance. Where necessary, additional data may be required from processes upstream or downstream of the team's demonstration in their supply chains.
 - b. The following factors must be considered at minimum in the emissions assessment:
 - i. Energy use;
 - ii. Land-/water-use change;
 - iii. Process water;
 - iv. Material feedstocks;
 - v. Waste disposal;
 - vi. Transportation of materials and CO₂;
 - vii. Equipment emissions;
 - viii. CO₂ sequestration management (including potential leaks);
 - ix. Any co-products/by-products and their conventional emissions.

- c. XPRIZE may provide standardized, region-specific emissions factors for certain parameters to promote consistency between Teams. Teams will be responsible for preparing and submitting all other inventory data required to calculate the aforementioned indicators in their initial assessment. Teams must also provide qualitative analysis of social impact indicators and any other requested qualitative indicators.
 - d. Teams must specify sources of uncertainty for each parameter in the inventory. This could include measurement error, volatility, technical risk, or other factors. Teams must provide worst-, most-likely-, and best-case inputs for most if not all Team-supplied parameters to enable uncertainty analysis of the quantitative indicators.
 - e. Teams may exclude inputs expected to contribute less than 1% to each quantitative indicator in their worst-case scenarios from the calculations, although Teams must transparently report such exclusions.
 - f. All inventory data, calculations, analysis, and methodological choices will be subject to verification and updates by XPRIZE, the judges, and contractors.
4. Guidelines for the Calculation of Indicators and Impact:
- a. The following indicators will be calculated, referencing the demonstrated life cycle performance of each finalist's demonstration:
 - i. CO₂-equivalent emissions generated per gross tonne of CO₂ captured from the atmosphere/ocean and durably sequestered;
 - ii. Process energy use;
 - iii. Land use and/or water surface area use;
 - iv. Process water consumption or production;
 - v. Material consumption;
 - vi. Waste generation;
 - vii. Durability of sequestered CO₂;
 - viii. Possible pathways for, and the likelihood of, re-emission or leakage of sequestered CO₂;
 - ix. Discussion of scalability to a gigatonne scale, including expected performance and anticipated impacts;
 - x. Identification of potential impacts to local communities;
 - xi. Identification of other potential societal and environmental impacts.
 - b. All process emissions will be allocated to the carbon dioxide removal process, with separate reporting of avoided emissions arising from displacement of emissions associated with co-products or by-products.
 - c. The most significant impact categories associated with the process under question should be identified, and impact analysis conducted in order to determine:
 - i. The magnitude of impact;

- ii. Discussion of the severity of impact as the solution approaches gigatonne scale;
 - iii. Potential mitigation strategies for each impact category.
 - d. Final reports may include a discussion of:
 - i. The accuracy & precision of available data;
 - ii. How and the extent to which the process holistically decreases atmospheric CO₂ concentrations and key process emissions contributors;
 - iii. Environmental impacts that could arise from the non-GHG indicators calculated in the assessment;
 - iv. The scalability of the process to a gigatonne scale and key limiting factors;
 - v. Contributors to the general uncertainty and sensitivity of results;
 - vi. Potential mitigation plans for major identified issues, uncertainties, and sensitivities.

Appendix F. Cost Analysis

The objective of the Cost Analysis is to provide a methodical verification of each Finalist Team's performance claims, and independent calculation of key indicators, related to the "Cost Calculation" requirements of the competition. These are (see [Competition Guidelines](#) for more detail):

- Full cost of CO₂;
- Cost of Risk and Externalities;
- Revenue and Value.

The requirements for this analysis draws from methodologies and practices including techno-economic assessment (TEA), technical cost modeling, manufacturing cost estimation, financial accounting, and the Rules from Phase 1 of the XPRIZE competition.⁴ Assessment results will inform the judging process, and high-quality data and transparency about uncertainty are required. The assessment will also inform the verification plans.

1. Assessment Process:

The assessment will be guided by the following process:

- a. Teams will submit an initial cost inventory as part of their Finalist Application;
- b. Judges will select finalist Teams using the initial submission;
- c. Independent contractors hired by XPRIZE will evaluate the initial submissions from the Finalists. The evaluation will inform verification plans for the demonstration projects, and flag any additional information or data that may be needed to complete the Assessment;

⁴ For more information please refer to the following:

Langhorst, T., McCord, S., Zimmermann, et. al (2022). *Techno-Economic Assessment & Life-Cycle Assessment Guidelines for CO₂ Utilization (Version 2.0)*. Global CO₂ Initiative, University of Michigan. <https://dx.doi.org/10.7302/4190>

Kobos, P. H., Drennen, T. E., Outkin, A. S., Webb, E. K., Paap, S. M., Wiryadinata, S. (2020). *Techno-Economic Analysis: Best Practices and Assessment Tools*. Sandia National Laboratories, US Department of Energy.

Christensen, P., Dysdert, L. R. (2005). *Cost Estimate Classification System - As Applied in Engineering, Procurement, and Construction for the Process Industries*. AACE International Recommended Best Practices.

Sinnott, R., & Towler, G. (2020). *Chapter 6: Costing and Project Evaluation*. In *Chemical Engineering Design* (pp. 275–369). Elsevier. <https://doi.org/10.1016/B978-0-08-102599-4.00006-0>

IEAGHG. (2021). *Towards improved guidelines for cost evaluation of carbon capture and storage*. 2021-TR05. IEAGHG

- d. Additional analysis and modeling will be completed as necessary to compute the required indicators;
 - e. Once verified data is available, the analysis will be finalized.
 - f. By the end of the competition demonstration period, contractors will produce a final report summarizing their findings.
2. Scope of Assessment includes:
- a. Calculate the indicators noted in section 4.
 - b. A functional unit/reference flow of one metric ton of carbon dioxide removed from the atmosphere/ocean and durably sequestered.
 - c. Cradle-to-grave impacts associated with the system, including as many relevant system components as possible, and durable (≥ 100 -year) sequestration of the CO₂ captured from the atmosphere/ocean.
 - d. Principles of operation and performance expectations consistent with the 1,000-metric-ton-per-year CDR demonstration, but with consideration of anticipated and reasonable performance and cost improvements as the solution scales to 1,000,000 metric tons of net CO₂ removed per year.
 - e. Assume that the 'megatonne scale' project begins construction today, from scratch, in USD, and using 2023-2024 technology and costs.
 - f. Quantification of uncertainty ranges for all applicable indicators, identifying the parameters whose uncertainty has the most significant impact on final indicators. Where quantification is not possible, other indicators of quality may be discussed.
 - g. Assessment of sensitivity to identify the parameters to which the final indicators are the most sensitive.
 - h. Discussion of challenges faced when conducting the assessment and possible data gaps.
3. Inventory Data Requirements:
- a. Cost inventories must include:
 - i. Capital costs: This includes the 'bare erected cost' of equipment and facilities; engineering, procurement, construction (EPC) costs related to commissioning the project; and the cost of acquiring land.
 - ii. Operational costs: All fixed and variable costs related to the operation of the carbon dioxide removal project including feedstocks & other raw materials, energy, fuel, labor, transportation, waste disposal.
 - iii. Costs related to monitoring and maintenance of the sequestered CO₂ over time to ensure that, on net, the sequestered CO₂ remains sequestered durably (as CO₂ or in another chemical form) for at least 100 years.

- iv. End of Project Costs include all decommissioning & disposal costs, rehabilitation of all land and other ecosystems impacted by the system, and any ongoing monitoring & verification obligations required to ensure 100-year durability of the sequestered CO₂.
 - v. Revenues may include any valuable, quantifiable product or service produced by the carbon dioxide removal project. Grants, subsidies, and the sale of CO₂ offsets may not be included.
 - vi. Any tangible & measurable environmental co-benefits (e.g. improved biodiversity, improved crop yields, improved fisheries, ecosystem services, removal of other greenhouse gasses, etc.) may be discussed.
- b. Inventory data must be provided with reference to a complete and detailed Process Flow Diagram, associated stream tables, and mass & energy balance associated with a 'megatonne scale' scenario.
 - c. Improvements of the technical performance and lifecycle emissions related to the 'megatonne scale' scenario under consideration in the cost analysis must be explicitly specified and justified, with reference to the system demonstrated today.
 - d. XPRIZE may provide standardized, region-specific cost factors for certain parameters to promote consistency between Teams. Teams will be responsible for preparing and submitting all other inventory data required to calculate the aforementioned indicators in their initial assessment. Teams must also provide qualitative analysis of externalities and risks if relevant.
 - e. Cost estimates provided by teams should be provided with as much precision as is reasonable for the current state of development of the technology. 'Order of magnitude' levels of accuracy (between -30% to +50%, in line with the ACE Class 4 estimation standard) are acceptable. Any of the following estimation methodologies may be used. They are listed here in order of preference:
 - 1. Vendor Quotes
 - 2. Comparative or Parametric estimating methods
 - 3. Scaling Factors
 - 4. Stochastic methods (Lang Factors, Hand Factors, etc)
 - 5. Cost databases (Public data is preferable to private data)
 - f. Teams must specify sources of uncertainty for each parameter in the inventory. This could include measurement error, volatility, technical risk, or other factors. Teams must provide worst-, most-likely-, and best-case inputs for most if not all team-supplied parameters to enable uncertainty analysis of the quantitative indicators.
 - g. Teams may exclude inputs expected to contribute less than 1% to each quantitative indicator in their worst-case scenarios from the calculations, although Teams must transparently report such exclusions.

- h. All inventory data, calculations, analysis, and methodological choices will be subject to further verification and updates by XPRIZE, the judges, and contractors.
4. Guidelines for the Calculation of Indicators:
- The calculation of indicators should be completed first and foremost in accordance with the competition guidelines and rules and in particular the points listed below. Where the competition guidelines and rules are not definitive, recognized standards, best practices, or first principles must be referenced.
- a. The following indicators will be calculated:
 - i. Fully considered cost per metric ton of net CO₂ removed from the atmosphere/ocean and durably sequestered;
 - ii. Non-CO₂-removal revenue generated by co-products, by-products, and/or other services provided by the process;
 - iii. Discussion of positive externalities associated with the process and calculation of any related revenues or value to society;
 - iv. Discussion of negative externalities associated with the process and calculation of any related mitigation costs;
 - v. Discussion of risks faced by the process and calculation of any related mitigation costs;
 - vi. Other indicators may be included in the final analysis, as recommended by verification contractors and/or the judges.
 - b. The total estimated capital cost shall be converted to an annual operating cost capital recovery factor, which is calculated as 20% of the Capital Costs and added to the Fixed Operating costs for every year the project operates. The capital recovery factor is meant to provide a consistent means to account for the capital costs, as well as all 'soft costs' related to the project, including taxes, depreciation, insurance, cost of capital, all other owner's costs, and contingencies.⁵
 - c. When researching pricing information, use the following guidelines:

⁵ For more information please refer to the following:

AFARA. (2021). *Background on Capital Recovery Factor used in XPRIZE Carbon Removal Cost Methodology*. XPRIZE, Milestone Submission Supplemental Resources. https://pop.xprize.org/prizes/xprize_carbon_capture/resources

Langhorst, T., McCord, S., Zimmermann, et. al (2022). *Techno-Economic Assessment & Life-Cycle Assessment Guidelines for CO₂ Utilization (Version 2.0)*. Global CO₂ Initiative, University of Michigan. <https://dx.doi.org/10.7302/4190>

NETL. (2011). *Quality guidelines for energy systems studies: cost estimation methodology for NETL assessments of power plant performance*. U.S. Department of Energy, National Energy Technology Laboratory. (Report DOE/NETL-2011/1455).

- i. Every effort should be made to produce cost estimates that are recent (2023 or newer). A common basis year should be used wherever possible.
- ii. Where recent estimates are unavailable, the consumer price index, GDP deflator, or similar method (as appropriate) may be used to correct older values.
- iii. If prices are volatile (year-over-year variations of 20% or more) a 5-year average should be used.
- iv. All pricing values should be provided for a consistent region. Local values should be used wherever possible, in the following order of preference:
 1. FOB Project Location;
 2. Country Values;
 3. Regional values;
 4. Global averages should only be used where regional values are unavailable.