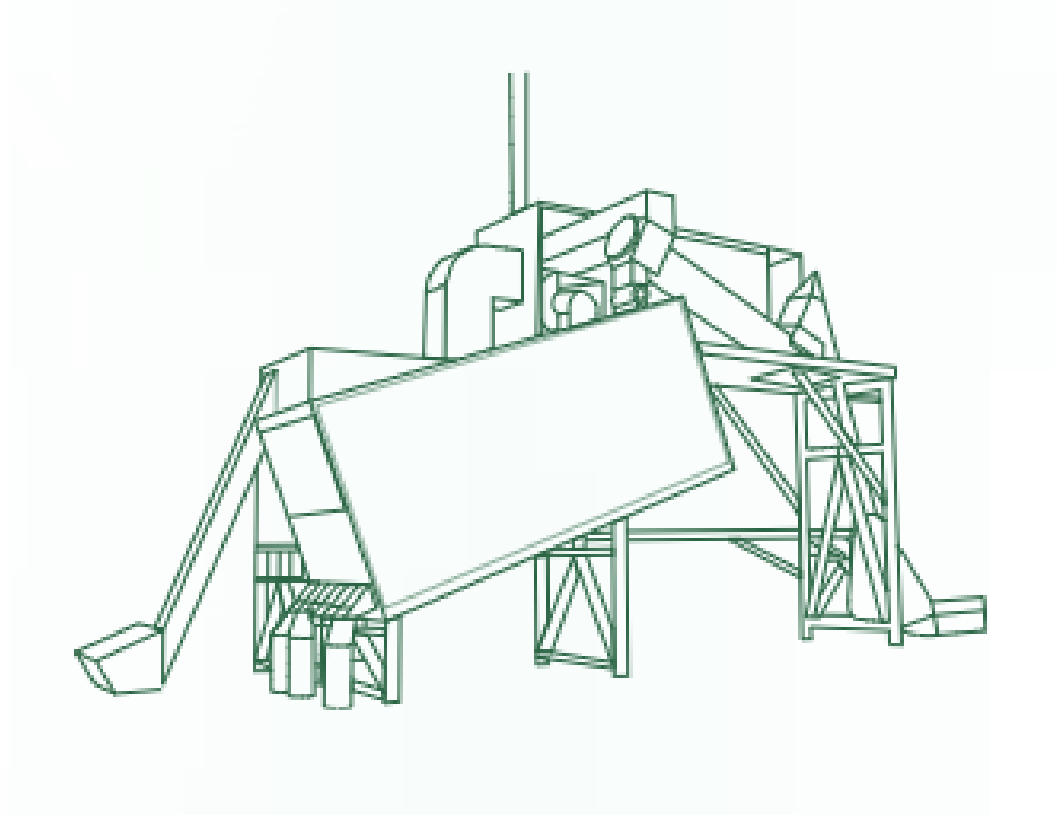
Isometric Project Design Document

Version 1.7

This PDD template follows the Isometric Standard. Please refer to the Standard for more information on how PDDs are used as part of the procedures of the Isometric Registry.

Section A – Key Project Data

A.1 Title
Please provide the title of your Project. This will be displayed as your Project's name on the Isometric Registry and all related documentation.
Carboneers & Terrafront High Tech Biochar



A.2 Description

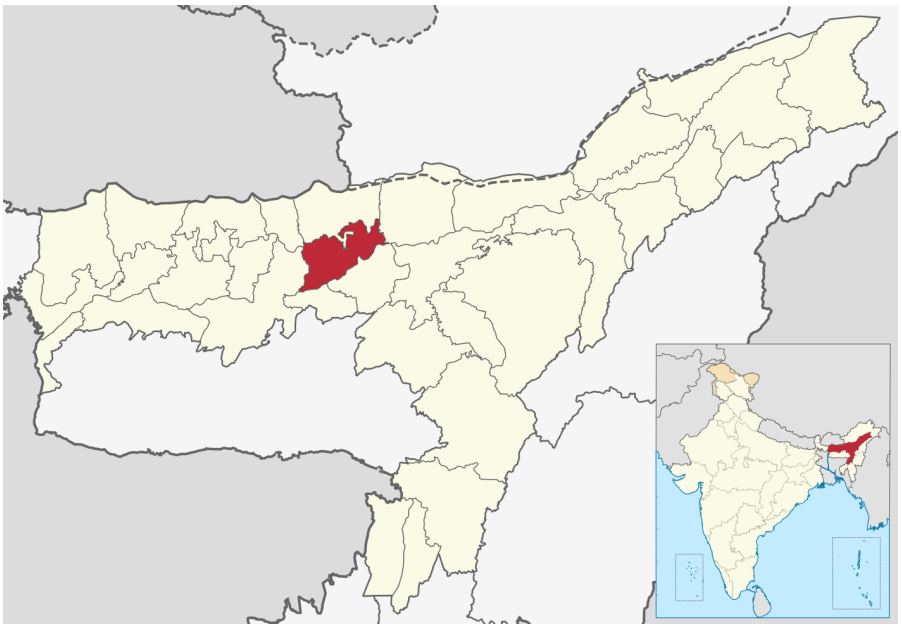
Please provide a brief description (50-100 words) of your carbon removal Project. A more detailed written technical description must be provided later.

Carboneers and Terrafront partner with smallholder farmers in Assam, India, to produce biochar primarily (~70%) from paddy straw waste streams (rice husk and stalk, also referred to as rice straw) with a minor fraction coming from cotton stalks (~20%) and corn stover (~10%). Using a centralized, high-tech pyrolysis facility tweaked to maximize biochar yield and quality (focused on permanence), the process ensures emissions control, efficiency, quality, and operator safety.
Once produced, the biochar is mixed with compost or manure and transported back to the farmers who will be responsible for application to nearby fields. This project has the potential to remove initially 2500 tons of CO2 annually per plant, with each removed ton generating one carbon credit. An initial 5 plants will be commissioned in Q4 2025, with an additional 20 plants expected to be built by 2026. We expect to generate 12.5k credits from the commissioned plants in 2025, growing the number to 50k credits in 2026.

A.3 Project Location(s)

- *Please submit at least one Address and/or specific geo-coordinates for the project.*
- *You may submit multiple Project locations – please specify what role each location plays in the Project.*

- The project location of the first plant(s) is the Darrang District in Assam, India. This is where the high tech pyrolysis production center will be located, with feedstock coming from surrounding areas (Max 25 KM).
  In the map you could see the district where the pyrolysis plant will be located. The sourcing and application area is now determined as the district.



A.4 Project Participants

Please provide a complete list of organizations participating in the project, with a contact person for each organization. (*Please duplicate the below rows for each additional organization you wish to add)*
Company registration number (*Unique business identification number in your country of registration*): Carboneers United B.V. - CoC: 89260724.
Organization Name: Carboneers
Organization Address. Maliebaan 77, Utrecht, the Netherlands
Contact Person: Berend De Haas
Contact Email Address: berend@carboneers.earth
Contact Phone Number: XXXXXXXX
Organization role in Project: Director

Company registration number (*Unique business identification number in your country of registration*): Terrafront Ventures- Fzco (DSO-FZCO-42082)
Organization Name: Terrafront
Organization Address: IFZA Business Park, Dubai Digital Park Premises Number 44255 - 001, Dubai Silicon Oasis Dubai, United Arab Emirates
Contact Person: Aarnav Aggarwal
Contact Email Address: admin@terrafrontventures.com
Contact Phone Number: XXXXXXXX
Organization role in Project: Director

A.5 Legal ownership of carbon removal claims
Please provide reasoning and evidence for legal ownership over the rights to all removals that will be claimed from the Project and refer to Section 3.1 "Ownership" of the Isometric Standard.
Carboneers holds legal ownership over the rights to all removals that will be claimed from the Project.

To avoid double counting, contracts with farmers are signed to ensure Carboneers is the only legal owner of the carbon removal credits generated from the project.

A.6 Technical description of Project activity

Please provide a brief technical description of your carbon removal Project activity in accessible language. This should include information on facilities and equipment, the age and average lifespan of equipment, and all further information essential to understanding how carbon removal is achieved by the Project.

Carboneers, in partnership with Terrafront, is implementing a centralized biochar production project in Assam, India, focusing on waste streams from nearby agricultural activities such as rice production. These residues are typically burned in the field or left to decompose, releasing the biogenic CO2 back into the atmosphere along with other greenhouse gasses such as methane, carbon monoxide, sulfur dioxide and particulate matter, hurting air quality in local communities. The project aims at transforming these harvest residues into biochar for soil application, thus preventing the release of GHGs and removing CO2 from the atmosphere for at least 1000 years.

Key technical aspects of the project include:

1. **Biomass**: Paddy straw, cotton stalks, and maize stalks will all be utilized in this project in an estimated 70/20/10 % share, respectively.

- All information surrounding feedstock type, sourcing, eligibility, etc.. can be found in the *feedstock annex* (x).

2. **Facility**: For this centralized project, we will be building a stationary pyrolysis facility designed by a European Engineering team and manufactured by an Indian Engineering team configured to maximize biochar yield while still ensuring pyrolysis conditions that deliver high quality biochar that satisfy the inertinite benchmark.
    - An initial 5 plant will be commissioned in 2025
    - An additional 20 plants are planned to be commissioned throughout 2026.
    - Each facility will be run for approximately 6500 hours per year.
    - Each plant is expected to produce roughly 2475 credits per year.
    - Each plant has an expected life expectancy of 5 years

3. **Equipment**: Each plant consists of an auger screw type pyrolyzer with a 3m3 hourly biomass throughput and 200kg biochar hourly. Syngas is combusted and the energy is partially recycled to sustain the pyrolysis process and partially utilized for external drying. A series of onboard thermocouples and pressure sensors gather data which is actively displayed on the control panel. Emission tests are conducted semi-continuously through annual tests which are crosschecked between production facilities.

- An extensive equipment description including reactor details, engineering diagrams, sensor positions, construction considerations, emissions tests, leakage accounting, and maintenance plans are presented in the pyrolysis reactor technical description in the *biochar production and storage* annex (x).

4. **Sample Monitoring**: In this project we ensure safe and durable biochar production and application by analyzing our biochar using the inertinite benchmark and checking for potential contaminants on a regular basis.

- A detailed description outlining environmental safeguards along with biochar sampling and analytical procedures and frequencies can be found in the *biochar production and storage* annex (x).

5. **Process monitoring MRV Application:** The project mobile application will ensure data is collected and stored for each step in the whole production process. From biomass loading and transportation of each feedstock and biochar batch to hourly data input of active pyrolysis information (temperature + pressure), the app will maintain an accurate overview of the general material inventory, transportation distances, and pyrolysis conditions based on thermocouple and pressure data.
- A complete description of the process monitoring plan and data flow is presented in the Monitoring plan MRV appendix. The application will still be amended to include hourly reactor data input photos and text recognition.

6. **Biochar Application**: Upon delivery of biochar to the respective farmers, project supervisors will oversee that the biochar is appropriately charged with a source of nutrients (manure, compost, etc.). Supervisors will re-visit the farm after biochar inoculation (2-3 weeks) and supervise the application of the charged biochar in the soil, ensuring the best practices are met that would ensure the agronomic benefits of the biochar produced and applied and that the carbon remains safely stored in the soil.

A.7 Declaration of exclusive registration

Please confirm that your Project may only claim credits for activities that are exclusively registered with the Isometric Registry.

●	I confirm the Project for which I aim to generate credits under the Isometric Standard is not registered with any other voluntary or compliance scheme.

A.8 Public funding

Please describe briefly whether your Project has received any public funding, e.g., grants or subsidies

The project has not received any public funding

A.9 Estimated carbon removal capacity

Please give an estimate of the net carbon removal capacity of this project in the coming years (metric tonnes)

Year	Estimated carbon removal capacity (net metric tonnes)
2025	12,500
2026	25,000

2027	50,000
2028	200,000
2029	500,000
2030	1,000,000

Section B – Protocol and Monitoring Data

B.1 Selected Certified Protocol	
Please select the Isometric Certified Protocol you wish to use for this Project. *Please note that, as per the Isometric Standard, you must use the latest available version of a Certified Protocol, unless a grace period has been explicitly specified by Isometric, whereby a former version of a Protocol may continue to be used for a defined time period.*	
Protocol Name: Biochar Production and Storage	
Protocol Version Number: 1.0	
•	I confirm that I am using the most recent available Certified Protocol version, or that a grace period has been explicitly specified allowing the use of an earlier protocol version.

B.2 Project Eligibility
Please explain why this Project is eligible under the selected Protocol.
The project removes CO2 from the atmosphere by producing biochar with farming communities in India. By utilizing waste feedstocks which were formerly burned in open environments, and utilizing them to produce highly stable biochar for agricultural purposes, this project satisfies eligibility criteria for Isometric's Biochar production and Storage protocol.

B.3 Acknowledgement of responsibility for providing notification of changes to operations	
Please confirm that you acknowledge responsibility for notifying Isometric of changes to operations which deviate from this submitted PDD	
•	We acknowledge responsibility for notifying Isometric of any changes to operations

B.4 Project Boundary

Please provide a description of the project boundary and complete the below table, including all GHGs considered across all Sources, Sinks and Reservoirs (SSRs) in both the Project and Baseline scenario. An appropriate level of detail on the scope of each individual GHG SSR that was studied should be clearly set out. Robust justification and appropriate evidence must be provided for any GHG SSRs that have been excluded from the project boundary. Evidence may be documented here or appended to the GHG Statement or PDD separately.

Additionally, you may also provide a diagram of the project boundary.

Description of Project boundary:

The project boundary encompasses the activities related to biochar production in Assam, India. The boundary includes:

- Biomass collection by smallholder farmers
- Biomass transportation fuel emissions
- Facility construction emissions
- Biochar production emissions
- Electricity consumption at production plant
- Biochar transportation fuel emissions
- Application of the biochar mixture to nearby fields
- Sample Transportation emissions for lab analysis

The project is developed and managed by Carboneers and Terrafront with support from the local farming community. Carboneers is responsible for project development, management, science, and sales, while Terrafront is responsible for investments, manufacturing of plants, monitoring software, and operations. Carboneers and Terrafront jointly manage technology development and financial planning.

The project boundary does not include individual air and road travel made by Carboneers and Terrafront when visiting the project locations, as these emissions are offset separately by the company as part of regular business activities.

[Optional] Project boundary diagram:

Baseline / Project	**Carbon Flux / Emission Source**	**Included/ excluded from project boundary?**	**Green house Gasses**	**Justification/description**
Project	Construction and	Included	CO_2	Material footprints of reactor production (steel), infrastructure development

	deployment of pyrolysis plant and facility			(cement/wood/aluminium), and solar panel installation included in LCA and subtracted for each ton of biochar produced over the lifetime of the facility.
Project	Transportation	Included	CO_2	Tractor (diesel) emissions from biomass transport to facility and biochar back to farms. Biochar and feedstock sample transport to laboratories (flights).
Project	Electricity	Excluded	CO_2	Solar electricity utilized onsite for all auxiliary equipment.
Project	Emissions from pyrolysis.	Included	CO_2, CH_4, CO, C_xH_x	The pyrolysis process will generate syngas which is then combusted within the combustion chamber. The main products post combustion are heat, CO2, CO, and trace amounts of uncombusted hydrocarbons. This CO2 is classified as biogenic, representing a carbon-neutral emission pathway (as it would have been returned to the atmosphere when burning or letting it decompose on the field during business as usual farming operations). Unlike fossil fuel-derived carbon dioxide, biogenic CO2 originates from recently sequestered biomass and is part of the natural carbon cycle, effectively returning to the atmospheric carbon pool without introducing additional long-term carbon inventory. The primary emissions concern during pyrolysis is methane generation, which can occur during incomplete thermal decomposition at suboptimal temperature ranges (most notably during startup and cooling). To monitor and mitigate potential methane emissions, initial process optimization and subsequent annual emissions testing will take place to calculate emission factors for all carbon-containing gasses.
Baseline	Decomposition of cotton harvest residues	Included	CH4, N2O, CO2,	In India, the majority (~77%) of rice straw is usually burned[1,2] with the remaining 9% being used for cattle applications (mostly bedding given the poor nutritional quality), 3% for domestic use as cooking fuel and roofing material, 5% used in composting, 2% left in the fields, 3% on commercial applications such as power and heat generation plants and 1% for other applications such as brick ovens, pottery or

[1] Singh, R., Srivastava, M., & Shukla, A. (2016). Environmental sustainability of bioethanol production from rice straw in India: A review. *Renewable and Sustainable Energy Reviews*, *54*, 202-216. https://doi.org/10.1016/j.rser.2015.10.005

[2] Parihar, D.S., Narang, M.K., Dogra, B., Prakash, A. and Mahadik, A., 2023. Rice residue burning in northern India: an assessment of environmental concerns and potential solutions–a review. *Environmental Research Communications*, *5*(6), p.062001.

				just thrown away[3]. Rice residues (straw and husk) nutrition content is typically poor and typically used as bedding for cattle and rarely used as animal food[4]. However, the small fraction of it is left in the fields to decompose releases the biogenic carbon back into the atmosphere, representing a considerable missed opportunity to sequester that carbon in a stable form for centuries, thus helping mitigate climate change caused by the uptick of greenhouse gases. Beyond CO2, the decomposition of these harvest residues also releases other greenhouse gasses that have a larger greenhouse warming effect such as CH4 and N2O. The baseline emission scenarios from decomposition are broken down by the different feedstocks: **1. Paddy Straw** Rice straw, the primary by-product of paddy harvesting, poses a significant environmental challenge in India and globally. For every kilogram of milled rice, approximately 0.7-1.4 kg of straw is produced, resulting in an annual global generation of 800-1000 million tons, with Asia accounting for 600-800 million tons[5]. Despite its abundance, rice straw has limited utility. Its high silica and lignin content, coupled with low protein and high oxalate levels, make it unsuitable for animal feed. Consequently, farmers often resort to open-field burning as a quick disposal method. This widespread burning practice, particularly prevalent in India due to its vast rice production, has become a major concern for both climate change and air quality. The practice releases significant amounts of greenhouse gases and particulate matter, contributing to global warming and severe air pollution.

[3] Singh, R., Srivastava, M., & Shukla, A. (2016). Environmental sustainability of bioethanol production from rice straw in India: A review. *Renewable and Sustainable Energy Reviews*, *54*, 202-216. https://doi.org/10.1016/j.rser.2015.10.005

[4] Pode, R. (2015). Potential applications of rice husk ash waste from rice husk biomass power plant. *Renewable and Sustainable Energy Reviews*, *53*, 1468-1485. https://doi.org/10.1016/j.rser.2015.09.051

[5] Kumar, V., Singh, P., Sharma, J. *et al.* Rice straw management through biofuel, biochar, mushroom cultivation, and paper production to overcome environmental pollution in North India. *Waste Dispos. Sustain. Energy* **5**, 483–510 (2023). https://doi.org/10.1007/s42768-023-00152-4

				The lack of cost-effective alternatives for straw management has exacerbated this problem, turning a potential resource into a harmful waste stream. This situation underscores the urgent need for innovative solutions to manage rice straw sustainably, both to mitigate its environmental impact and to potentially harness it as a valuable resource. **2. Corn Stover** In many agricultural regions of India, particularly in areas where corn is a major crop, the management of harvest residues presents an ongoing challenge. After the corn harvest, substantial amounts of plant material remain in the fields. While a portion of these residues is utilized as animal fodder, a significant quantity is left unused. In the absence of alternative uses or efficient collection systems, farmers often resort to leaving these residues in the field to decompose naturally or, in some cases, burning them. This practice is especially prevalent in remote and less industrialized areas of the country. These regions typically lack the infrastructure and industrial network necessary to efficiently collect and repurpose the corn residues for alternative uses. As a result, the decomposition or burning of these materials becomes the default option for many farmers. The decision to burn residues is often driven by the need to clear fields quickly for the next planting cycle, despite the known environmental and health risks associated with this practice. The natural decomposition of residues, while less harmful than burning, can be a slow process and may interfere with subsequent agricultural activities. This situation highlights the need for developing more sustainable and economically viable solutions for managing agricultural residues in India's rural and remote corn-growing regions[6]. **Conclusion** By converting paddy straw, rice husk, and corn stover to biochar instead of allowing them to decompose, the project activity would potentially

[6] Bhuvaneshwari, S., Hettiarachchi, H. and Meegoda, J.N., 2019. Crop residue burning in India: policy challenges and potential solutions. *International journal of environmental research and public health*, *16*(5), p.832.

				reduce these baseline GHG emissions. Biochar production would stabilize a significant portion of the carbon in the biomass wastestreams, preventing its release as CO2 during decomposition. Additionally, it would likely reduce CH4 and N2O emissions that occur during natural decomposition processes. Furthermore, the application of biochar to soil will have an additional GHG mitigation effect. Biochar in the soil can prevent the leaching of plant available nutrients and release of GHGs (including inorganic-N leaching, N2O emissions, and ammonia volatilization) from the decomposition of organic material already present in the soil at the moment of application[7,8]. Thus, biochar application not only removes carbon from the feedstocks its made of but also helps to stabilize existing soil organic matter, providing a dual benefit in terms of GHG emission reduction[9].
Baseline	Open field burning of cotton harvest residues	Included	PM, SO2 , NOx, NH3 , CH4 , BC, OC, VOC, CO, CO2[10]	**1. Rice Straw (70%) and Rice Husk (20%)** Rice straw, the primary by-product of paddy harvesting, poses a significant environmental challenge in India and globally. For every kilogram of milled rice, approximately 0.7-1.4 kg of straw is produced, resulting in an annual global generation of 800-1000 million tons, with Asia accounting for 600-800 million tons[11]. Despite its abundance, rice straw has limited utility. Its high silica and lignin content, coupled with low protein and high oxalate levels, make it unsuitable for animal feed. Consequently, farmers often resort

[7] Singh, B.P.; Hatton, B.J.; Singh, B.; Cowie, A.L.; Kathuria, A. Influence of biochars on nitrous oxide emission and nitrogen leaching from two contrasting soils. J. Environ. Qual. 2010, 39, 1224–1235.
[8] Spokas, K.; Reicosky, D.C. Impacts of sixteen different biochars on soil greenhouse gas production. Ann. Environ. Sci. 2009, 3, 179–193.
[9] Tao, Y., Feng, W., He, Z., Wang, B., Yang, F., Nafsun, A.I. and Zhang, Y., 2024. Utilization of cotton byproduct-derived biochar: a review on soil remediation and carbon sequestration. Environmental Sciences Europe, 36(1), p.79.
[10] Cao, G., Zhang, X., Wang, Y. and Zheng, F., 2008. Estimation of emissions from field burning of crop straw in China. Chinese Science Bulletin, 53, pp.784-790.
[11] Kumar, V., Singh, P., Sharma, J. *et al.* Rice straw management through biofuel, biochar, mushroom cultivation, and paper production to overcome environmental pollution in North India. *Waste Dispos. Sustain. Energy* **5**, 483–510 (2023). https://doi.org/10.1007/s42768-023-00152-4

				to open-field burning as a quick disposal method. This widespread burning practice, particularly prevalent in India due to its vast rice production, has become a major concern for both climate change and air quality. waste burning practice releases substantial environmental pollutants, including greenhouse gases (CO2, CH4, N2O) and hazardous air contaminants like particulate matter (soot), halides (hydrogen chloride), and toxic compounds (dioxins/furans), resulting in significant atmospheric degradation and air quality deterioration[12]. **2. Corn Stover (10%)** In many agricultural regions of India, particularly in areas where corn is a major crop, the management of harvest residues presents an ongoing challenge. After the corn harvest, substantial amounts of plant material remain in the fields. While a portion of these residues is utilized as animal fodder, a significant quantity is left unused. In the absence of alternative uses or efficient collection systems, farmers often resort to leaving these residues in the field to decompose naturally or, in some cases, burning them. This practice is especially prevalent in remote and less industrialized areas of the country. These regions typically lack the infrastructure and industrial network necessary to efficiently collect and repurpose the corn residues for alternative uses. As a result, the decomposition or burning of these materials becomes the default option for many farmers. The decision to burn residues is often driven by the need to clear fields quickly for the next planting cycle, despite the known environmental and health risks associated with this practice. The natural decomposition of residues, while less harmful than burning, can be a slow process and may interfere with subsequent agricultural activities. This situation highlights the need for developing more sustainable and economically viable solutions for managing agricultural residues in India's rural and remote corn-growing regions[13].

[12] Tsai, C., Shen, Y., & Tsai, W. Thermochemical Characterization of Rice-Derived Residues for Fuel Use and Its Potential for Slagging Tendency. *Fire*, *6*(6), 230. https://doi.org/10.3390/fire6060230

[13] Bhuvaneshwari, S., Hettiarachchi, H. and Meegoda, J.N., 2019. Crop residue burning in India: policy challenges and potential solutions. *International journal of environmental research and public health*, *16*(5), p.832.

B.5 Baseline scenario

Please describe the baseline scenario of what would have happened if your Project did not take place (refer to Section 2.5.2 "Baselines" of the Isometric Standard and the requirements outlined in the relevant Protocol). Projects will only be credited for Removals above this counterfactual baseline.

Emissions baseline

In the absence of this project, the baseline scenario would involve the natural and uncontrolled processes of carbon release from biomass. This includes:

1. **Biogenic CO2 Emissions**:
   - Without the project, the carbon contained in the biomass would be released into the atmosphere through natural decomposition, burning, or other feed routes. These emissions are considered biogenic, meaning they originate from organic sources and would eventually result in the release of CO2 into the atmosphere. For detailed baseline values, see the section above.

2. **Methane Emissions**:
   - Methane, having a significantly higher global warming potential than CO2, would also be released in higher quantities without the project. In perfect pyrolysis conditions, methane emissions should be nearly non-existent due to the gas being highly flammable and burning off in the process. However, natural decomposition and open field burning of biomass would lead to higher methane emissions.

Baseline Practices and Project Interventions

1. **Biomass Decomposition or Burning**:
   - Without the project, biomass would either decompose naturally or most likely be subjected to open burning practices. To mitigate this, farmers participating in the project are required to sign a contract that prohibits open field burning (The wording of the contract can be found in Annex A). This contractual obligation is part of our onboarding process, where farmers create profiles in our mobile application, agree to the terms, and sign the declaration digitally.
   - Farmers that are seen incurring in open field burning while in the project are excluded from further participation in biochar production.

Baseline Scenario Emissions 1 - Decomposition of Harvest Residues

In the baseline scenario where some cotton stalks are left to decompose in the field, the following greenhouse gases (GHGs) and associated emissions are considered (these values are estimations based on soil temperature, lignin, cellulose and hemicellulose contents as no emissions have been reported in the literature as of 2024):

Paddy Straw

- ***Paddy Straw Carbon Dioxide (CO2) emissions from decomposition***

The primary GHG emitted during the decomposition process is CO2. Based on reference values, the released CO2 from decomposition of paddy straw would be:

1. *Paddy straw composition*[14],[15]:
    a. Cellulose: 34%
    b. Hemicellulose: 30%
    c. Lignin: 10%
    d. Total easily decomposable material (cellulose + hemicellulose): 64%
2. *Theoretical maximum CO2 emissions:*
    a. 1 ton paddy straw = 640 kg cellulose + hemicellulose
    b. If fully decomposed: ~939 kg CO2 (640 kg × 44/30, where 44 is the molecular weight of CO2 and 30 is the rough molecular weight of cellulose/hemicellulose molecules[16])
3. *Actual decomposition rate*[17]*:*
    a. 55.6% decomposition after one year.
    b. That equals 522 kg biogenic CO2 per ton of paddy straw (939 kg × 55.6%)

Adjusting for real-world conditions, considering incomplete decomposition and soil incorporation of labile Carbon, we estimate emissions of 400-500 kg of biogenic CO2 per ton in the first year of paddy straw left in the field to decompose.

Although this does not represent a significant contribution to climate change as it is biogenic carbon, it does represent a missed opportunity to sequester that carbon in a stable solid form. Moreover, the higher decomposition rate of paddy straw compared to cotton stalks suggests a more rapid release of CO2, potentially leading to short-term spikes in local CO2 levels.

- ***Paddy Straw Methane (CH4) emissions from decomposition***

Assuming reported values for paddy straw:

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[14] Kumar, V., Singh, P., Sharma, J. *et al.* Rice straw management through biofuel, biochar, mushroom cultivation, and paper production to overcome environmental pollution in North India. *Waste Dispos. Sustain. Energy* **5**, 483–510 (2023). https://doi.org/10.1007/s42768-023-00152-4

[15] Yan, C., Yan, SS., Jia, TY. *et al.* Decomposition characteristics of rice straw returned to the soil in northeast China. *Nutr Cycl Agroecosyst* **114**, 211–224 (2019). https://doi.org/10.1007/s10705-019-09999-8

[16] Cellulose ($C_6H_{10}O_5$) has a carbon content of 44.4% by weight while Hemicellulose ($C_5H_8O_4$) has a carbon content of 42.1% by weight.

[17] IBID

1. Paddy straw composition[18]:
    a. Cellulose: 34% Hemicellulose: 30% Lignin: 10%
    b. Total easily decomposable material (cellulose + hemicellulose): 64%
2. Methane production potential:
    a. Methane is produced under anaerobic conditions
    b. Assuming 1-5% of decomposed carbon becomes methane (conservative estimate based on typical soil conditions)
3. Carbon content estimation:
    a. Assume ~45% carbon in cellulose and hemicellulose
    b. 1 ton paddy straw = 640 kg cellulose + hemicellulose
    c. Carbon available = 640 kg × 45% = 288 kg
4. First-year decomposition:
    a. 55.6% decomposition in first year[19]
    b. Carbon decomposed = 288 kg × 55.6% = 160.13 kg
5. Methane production estimate:
    a. 1-5% of decomposed carbon becomes methane
    b. Methane carbon = 160.13 kg × (1% to 5%) = 1.60 to 8.01 kg

Converting carbon to methane mass:

- Molecular weight ratio of CH4 to C is 16:12

Methane produced = (1.60 to 8.01 kg) × (16/12) = 2.13 to 10.68 kg CH4 per ton of paddy straw left to decompose

The methane Global Warming Potential for 100 years of this scenario can be calculated using the conversion factor of 27 for non fossil sources in the latest IPCC report[20].

*GWP100 = 2.13 to 10.68 * 27 (kg CO2-eq/ton) = 57.5 to 288 kg CO2eq per 1 ton of paddy straw left to decompose.*

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[18] Kumar, V., Singh, P., Sharma, J. *et al.* Rice straw management through biofuel, biochar, mushroom cultivation, and paper production to overcome environmental pollution in North India. *Waste Dispos. Sustain. Energy* **5**, 483–510 (2023). https://doi.org/10.1007/s42768-023-00152-4

[19] Yan, C., Yan, SS., Jia, TY. *et al.* Decomposition characteristics of rice straw returned to the soil in northeast China. *Nutr Cycl Agroecosyst* **114**, 211–224 (2019). https://doi.org/10.1007/s10705-019-09999-8

[20] Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021: Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In https://www.ipcc.ch/report/ar6/wg1/ [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 923–1054, doi:10.1017/9781009157896.009.

Corn Stalks

- ***Corn Stalks Carbon Dioxide (CO2) emissions from decomposition***

The primary GHG emitted during the decomposition process is CO2. Based on reference values, the released CO2 from decomposition of corn stalks would be:

1. *Corn stalk composition*[21]:
    1. Cellulose: 39%
    2. Hemicellulose: 19%
    3. Lignin: 23%
    4. Total easily decomposable material (cellulose + hemicellulose): 58%
2. *Theoretical maximum CO2 emissions*:
    1. 1 ton corn stalks = 580 kg cellulose + hemicellulose
    2. If fully decomposed: ~851 kg CO2 (580 kg × 44/30, where 44 is the molecular weight of CO2 and 30 is the rough molecular weight of cellulose/hemicellulose molecules[22])
3. *Actual decomposition rate*[23]:
    1. 75% decomposition after one year
    2. That equals 638 kg biogenic CO2 per ton of corn stalks (851 kg × 75%)

Adjusting for real-world conditions, considering incomplete decomposition and soil incorporation of labile Carbon, we estimate emissions of 550-650 kg of biogenic CO2 per ton in the first year of corn stalks left in the field to decompose.

Although this does not represent a significant contribution to climate change as it is biogenic carbon, it does represent a missed opportunity to sequester that carbon in a stable solid form. Moreover, the higher decomposition rate of corn stalks compared to paddy straw suggests an even more rapid release of CO2, potentially leading to more pronounced short-term spikes in local CO2 levels.

- ***Corn Stalks Methane (CH4) emissions from decomposition***:

1. Corn stalk composition[24]:

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[21] Raj, T., Kapoor, M., Gaur, R., Christopher, J., Lamba, B., Tuli, D.K. and Kumar, R., 2015. Physical and chemical characterization of various Indian agriculture residues for biofuels production. *Energy & Fuels*, *29*(5), pp.3111-3118.

[22] Cellulose ($C_6H_{10}O_5$) has a carbon content of 44.4% by weight while Hemicellulose ($C_5H_8O_4$) has a carbon content of 42.1% by weight.

[23] Lehman, R.M., Osborne, S.L., Prischmann-Voldseth, D.A. and Rosentrater, K.A., 2010. Insect-damaged corn stalks decompose at rates similar to Bt-protected, non-damaged corn stalks. *Plant and soil*, *333*, pp.481-490.

[24] Raj, T., Kapoor, M., Gaur, R., Christopher, J., Lamba, B., Tuli, D.K. and Kumar, R., 2015. Physical and chemical characterization of various Indian agriculture residues for biofuels production. *Energy & Fuels*, *29*(5), pp.3111-3118.

- Cellulose: 39%,
- Hemicellulose: 19%,
- Lignin: 23%
- Total easily decomposable material (cellulose + hemicellulose): 58%

2. Methane production potential:
   - Methane is produced under anaerobic conditions
   - Assuming 1-5% of decomposed carbon becomes methane (conservative estimate based on typical soil conditions)
3. Carbon content estimation:
   - Assume ~45% carbon in cellulose and hemicellulose
   - 1 ton corn stalks = 580 kg cellulose + hemicellulose
   - Carbon available = 580 kg × 45% = 261 kg
4. First-year decomposition:
   - 75% decomposition in first year[25]
   - Carbon decomposed = 261 kg × 75% = 195.75 kg
5. Methane production estimate:
   - 1-5% of decomposed carbon becomes methane
   - Methane carbon = 195.75 kg × (1% to 5%) = 1.96 to 9.79 kg

Converting carbon to methane mass:

- Molecular weight ratio of CH4 to C is 16:12

Methane produced = (1.96 to 9.79 kg) × (16/12) = 2.61 to 13.05 kg CH4 per ton of corn stalks left to decompose.

The methane Global Warming Potential for 100 years of this scenario can be calculated using the conversion factor of 27 for non fossil sources in the latest IPCC report[26].

*GWP100 = 2.61 to 13.05 * 27 (kg CO2-eq/ton) = to 70.4 to 352 kg CO2eq per 1 ton of corn straw left to decompose.*

[25] Lehman, R.M., Osborne, S.L., Prischmann-Voldseth, D.A. and Rosentrater, K.A., 2010. Insect-damaged corn stalks decompose at rates similar to Bt-protected, non-damaged corn stalks. *Plant and soil*, *333*, pp.481-490.

[26] Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021: Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In https://www.ipcc.ch/report/ar6/wg1/ [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 923–1054, doi:10.1017/9781009157896.009.

Baseline Scenario Emissions 2 - Open Field Burning of Harvest Residues

Paddy Straw

In the baseline scenario of open field burning of paddy straw, the following greenhouse gases (GHGs) and associated emissions are considered[27]:

2.1 Paddy Straw Carbon Dioxide (CO2) from burning:

The primary GHG emitted during open field burning Approximately 1460 kg of CO2 is released per ton of paddy straw burned. Although this does not represent a significant contribution to climate change as it is biogenic carbon, it does represent a missed opportunity to sequester that carbon in a stable solid form.

2.2 Paddy Straw Methane (CH4) from burning:

A potent GHG with a high global warming potential Emission rate of 4.51 kg per ton of paddy straw burned[28]

The methane Global Warming Potential for 100 years of this scenario can be calculated using the conversion factor of 27 for non fossil sources[29].

*GWP100 = 4.51 * 27 (kg CO2-eq/ton burned) = 121.8 kg CO2eq per 1 ton of burned paddy straw.*

2.3 Paddy Straw Nitrous Oxide (N2O) from burning:

Another potent GHG Emission rate of 0.07 kg per ton of paddy straw burned

The N2O Global Warming Potential for 100 years of this scenario can be calculated using the conversion factor of 273

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[27] Gadde, B., Bonnet, S., Menke, C. and Garivait, S., 2009. Air pollutant emissions from rice straw open field burning in India, Thailand and the Philippines. *Environmental Pollution*, *157*(5), pp.1554-1558.

[28] Romasanta, R.R., Sander, B.O., Gaihre, Y.K., Alberto, M.C., Gummert, M., Quilty, J., Castalone, A.G., Balingbing, C., Sandro, J., Correa Jr, T. and Wassmann, R., 2017. How does burning of rice straw affect CH4 and N2O emissions? A comparative experiment of different on-field straw management practices. *Agriculture, ecosystems & environment*, *239*, pp.143-153.

[29] Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021: Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In https://www.ipcc.ch/report/ar6/wg1/ [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 923–1054, doi:10.1017/9781009157896.009.

*GWP100 = 0.07 * 273 (kg CO2-eq/ton burned) = 731. 6 kg CO2eq per 1 ton of burned paddy straw.*

2.4 Paddy Straw Carbon Monoxide (CO) from burning:

While not a direct GHG, CO can indirectly affect climate by increasing the lifetime of CH4, making the short term greenhouse effect stronger.

The emission rate is 34.7 kg CO per ton of paddy straw burned

Thus, combined and removing the biogenic CO2 that would be released back into the atmopshere, the 100 year global warming potential for 1 ton of burned paddy straw is 121.8 + 731.6 = 853.4 kgs CO2 eq / ton .

Other emissions and particulates, though not direct GHGs, can have indirect climate impacts and negative environmental effects:

2.5 Paddy Straw Particulate Matter (PM) from burning

PM2.5 emission rate of 12.95 kg per ton of paddy straw burned PM10 emission rate of 3.7 kg per ton of paddy straw burned Includes crystalline silica, which has detrimental health effects

Corn Stover/Straw

In the baseline scenario of open field burning of corn stover, (a combination of mostly corn stalks and straw plus leaves and cobs left after harvesting), the following greenhouse gases (GHGs) and associated emissions are considered[30] [31] [32]:

3.1 Corn Straw Carbon Dioxide (CO2) from burning:

The primary GHG emitted during open field burning Approximately 2200 kg of CO2 is released per ton of corn straw burned.

Although this does not represent a significant contribution to climate change as it is biogenic carbon, it does represent a missed opportunity to sequester that carbon in a stable solid form.

3.2 Corn Straw Methane (CH4) from burning:

A potent GHG with a high global warming potential Emission rate of 1.93 kg per ton of

[30] Li, X., Wang, S., Duan, L., Hao, J., Li, C., Chen, Y. and Yang, L., 2007. Particulate and trace gas emissions from open burning of wheat straw and corn stover in China. *Environmental science & technology*, *41*(17), pp.6052-6058.
[31] Ni, H., Han, Y., Cao, J., Chen, L.W.A., Tian, J., Wang, X., Chow, J.C., Watson, J.G., Wang, Q., Wang, P. and Li, H., 2015. Emission characteristics of carbonaceous particles and trace gases from open burning of crop residues in China. *Atmospheric Environment*, *123*, pp.399-406.
[32] Hong, J., Ren, L., Hong, J. and Xu, C., 2016. Environmental impact assessment of corn straw utilization in China. *Journal of Cleaner Production*, *112*, pp.1700-1708.

paddy straw burned[33]

The methane Global Warming Potential for 100 years of this scenario can be calculated using the conversion factor of 27 for non fossil sources[34].

*GWP100 = 1.93 * 27 (kg CO2-eq/ton burned) = 52.11 kg CO2eq per 1 ton of burned paddy straw.*

3.3 Corn Straw Nitrous Oxide (N2O) from burning:

Another potent GHG Emission rate of 0.14 kg per ton of corn straw burned

The N2O Global Warming Potential for 100 years of this scenario can be calculated using the conversion factor of 273

*GWP100 = 0.14 * 273 (kg CO2-eq/ton burned) = 38.22 kg CO2eq per 1 ton of burned corn straw.*

3.4 Corn Straw Carbon Monoxide (CO) from burning:

While not a direct GHG, CO can indirectly affect climate change by increasing the lifetime of CH4, thus making the short term greenhouse effect behind global warming stronger.

The emission rate is 53 kg CO per ton of corn straw burned

Thus, combined and removing the biogenic CO2 that would be released back into the atmopshere, the 100 year global warming potential for 1 ton of burned corn straw is 52.11 + 38.22 = 90.3 kgs CO2 eq / ton .

Other emissions and particulates, though not direct GHGs, can have indirect climate impacts and negative environmental effects:

3.5 Corn Straw Particulate Matter (PM) from burning:

Total PM 2.5 emission rate of 15.7 kg per ton of corn straw burned and total PM10 emission rate of 9.69 kg per ton of corn straw burned.

Conclusion

The baseline scenarios of natural decomposition and open field burning of agricultural residues such as paddy straw, and corn stover present significant environmental and climate concerns. Both processes release substantial amounts of greenhouse gases,

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[33] EPA. 2020. National Emissions Inventory (NEI) documentation. Agricultural burning emission factor. https://www.epa.gov/air-emissions-inventories

[34] Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021: Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In https://www.ipcc.ch/report/ar6/wg1/ [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 923–1054, doi:10.1017/9781009157896.009.

primarily CO2, CH4, and N2O, contributing to climate change. While the CO2 emissions are considered biogenic and part of the natural carbon cycle, they represent a missed opportunity to sequester carbon in a more stable form.

Open field burning, in particular, poses additional environmental and health risks. Beyond greenhouse gas emissions, it produces harmful pollutants and particulate matter (PM2.5 and PM10) that negatively impact air quality and long human health in surrounding communities and even in far away cities, a particular concern in India, where this project takes place.

Moreover, open field burning results in the loss of valuable biochemical compounds present in the agricultural residues. The global warming potential (GWP) of these emissions, especially from methane and nitrous oxide, is considerable when factoring in their higher potency compared to CO2. This underscores the need for alternative management practices for agricultural residues that can mitigate these emissions while potentially offering additional benefits such as soil improvement and sustainable resource utilization.

B.6 Leakage Assessment

Please give a robust assessment of how you have considered potential increases in GHG emissions outside the defined Project boundary that occur as a result of the Project activity. Where the potential for such Leakage is identified, it must be quantified and deducted from the CO_2 Removals in accordance with the relevant Protocol. Please refer to Section 2.5.4 "Leakage" of the Isometric Standard.

Potential for Leakage and Mitigation Measures

1. Feedstock Selection and Usage:

- **Strict Feedstock Criteria**: Carboneers and Terrafront collaboratively implement a rigorous feedstock selection process to avoid any unintended increase in GHG emissions:
    - **No Use of Large Woody Material**: The project does not utilize large woody material, which could be repurposed for construction or other uses. This avoids the risk of inadvertently promoting the use of materials that might otherwise be used as fuel or deforestation.
    - **No Alternative Use Feedstock**: The feedstock used in the project consists solely of agricultural waste streams that hold no significant value to the farmers (or industry) which were previously burned as waste. This prevents the displacement of materials that might otherwise have an alternative use.

- **Satellite Imagery Monitoring**: In a later phase, the project will employ satellite imagery to cross-check biomass availability and usage, ensuring that the selected feedstock remains consistent with project guidelines and that there is no unintentional shift in biomass usage that could lead to increased deforestation or emissions elsewhere.
- To ensure that the project does not interfere with effective soil and farm management practices, such as crop rotations, a survey will be conducted with all

participating farmer groups to assess crop rotations over the past five years.

- If no crop rotations have occurred during this period, we will purchase residual biomass from farming community annually.

- If crop rotations have been practiced, biomass will only be acquired from the specific farms during the years when the feedstock considered for this project would have been planted. For example, if farmers have historically planted paddy straw in years 1, 3, and 5 of the last five years, the project will only acquire biomass in years 1, 3, and 5 moving forward.

- Details on feedstock accounting and supplier contracts can be found in the Biomass Feedstock Accounting Annex.

2. Economic and Social Benefits:

- **Smallholder Farmers**: The project provides an alternative income source for smallholder farmers during the off season. An expanded explanation of all the SDG cobenefits is provided in section D.5 of this document.

Quantification and Deduction of Leakage

- **Leakage Monitoring and Documentation**: To ensure that biochar is used as intended, the project mandates that all biochar applications be registered through our mobile application. This registration process includes capturing a photo, along with time, date, and GPS stamps, which will later be cross-checked with satellite imagery. This rigorous monitoring process ensures that any potential leakage is identified and addressed.

Other risk mitigations:

1. Risk of Biochar Usage as Cooking Fuel:

- **Assessment**: There is a minimal risk that the biochar produced within the project might be diverted for use as cooking fuel. However, this risk is significantly mitigated by the characteristics of the biochar produced:
  - **Calorific Value**: The biochar derived from agricultural biomass waste has a low calorific value, making it less suitable for use as a cooking fuel compared to woody biochars.
  - **Physical Characteristics**: The shape and form of the biochar produced are not conducive to its use as cooking fuel.
- **Mitigation Measures**:
  - **Farmer Training**: Farmers involved in the project are trained to mix biochar with compost or manure, reducing the likelihood of its misuse as cooking fuel. The Supervisor is present at the mixing and application.
  - The project requires that biochar application to soils be registered within the dMRV process, including photographic evidence and time, date, and GPS stamps to ensure proper use. This step is mandatory for the sink to be processed and the farmer to receive additional biochar(carbon removal only occurs when it is applied in a stable reservoir like soils).

Based on the above considerations, the potential for leakage is minimal, and where identified, it is mitigated through training, strict feedstock selection, and robust monitoring. Should any leakage be detected, it will be quantified and deducted from the CO2 removals in accordance with the relevant Protocol of the Isometric Standard.

B.7 Demonstration of Additionality

B.7.1 Demonstration of Additionality: Financial Additionality

Please describe and provide evidence for how your Project is financially additional. Refer to Section 2.5.3. "Additionality" of the Isometric Standard and the requirements outlined in the relevant Protocol.

Additionality is a core principle of our project. Prior to our intervention, there were no carbon removal practices in the area. Instead, open-field burning was prevalent, resulting in significant methane emissions.
The carbon credit revenue is the sole source of revenue for this project.

Upon joining our project, farmers sign a declaration of honor committing to cease open-field burning. Non-compliance results in project exclusion and loss of associated financial benefits. However, farmers retain the freedom to continue biochar production independently.

We have carefully assessed and mitigated potential indirect leakage. The biomass stream utilized was not previously employed for essential purposes such as cooking, thereby avoiding the risk of increased deforestation.

Financial additionality:

- **Primary revenue source:** Carbon credits are the sole source of income for the project.
- **Project dependency:** The project is entirely reliant on carbon credit revenue for its continuation.
- **Economic barriers:** Without the financial incentives provided by carbon credit sales, the project is not feasible due to limited to no ability of farmers to pay for biochar or heat produced by the plant. The upfront investment costs required to set up the plant are high for no other revenue stream present. Hence, without carbon credits revenues, the project would not have taken place..

The project effectively demonstrates all three pillars of additionality: financial, environmental, and regulatory. By addressing the economic barriers to biochar production and providing a clear environmental benefit through reduced methane emissions and carbon removal, the project qualifies as additional under the Isometric Standard and relevant protocols.

B.7.2 Demonstration of Additionality: Environmental Additionality

Please describe and provide evidence for how your Project is environmentally additional. Refer to Section 2.5.3. "Additionality" of the Isometric Standard and the requirements outlined in the relevant Protocol.

- **Baseline scenario:** Prior to the project, open-field burning of agri waste streams was the predominant practice, leading to substantial methane emissions (see section B4 of this document).
- **Project impact:** By incentivizing biochar production, the project effectively replaces open-field burning, resulting in a direct reduction of methane emissions and carbon removal through biochar.
- The project quantifies that during the first 5 years of operation, 12,000 tons of co2 per plant will be removed from the atmosphere and stored safely for centuries in the form of biochar, thus making the project a net negative initiative, after incorporating the emissions associated with the project itself such as pyrolysis emissions and biomass sourcing and biochar distribution to farmers.
- **Emission reduction from biochar in soil:** Even though we do not use these reference values for carbon credits, the scientific consensus is that after biochar application in the soil, the biochar further reduces emissions coming from agricultural systems[35]. Biochar application in soil reduces the greenhouse gas emissions from soil processes, further making the process a net negative activity:
    - **Enhanced Soil Structure**: Biochar improves soil aeration (by reducing bulk density and increasing pore connectivity) and water retention, creating a more stable environment for microbial activity. Biochar itself provides a habitat for soil microbes, further enhancing their activity and diversity. This can lead to more efficient decomposition processes and stabilization of organic matter, reducing the overall CO_2 flux
    - **Nitrification and Denitrification:** Nitrification and denitrification are key processes in the nitrogen cycle that produce nitrous oxide (N_2O)[36], a potent GHG.
        - **Nitrification**: Biochar can adsorb ammonium (NH_4^+) and nitrate (NO_3^-), reducing their availability for nitrifying bacteria. This can slow down the nitrification process, thereby reducing N_2O emissions
        - **Denitrification**: Biochar can increase soil moisture content, as well as increase the abundance of N_2O-reducing bacteria, all of which can promote the complete reduction of N_2O to nitrogen gas (N_2), thus reducing N_2O emissions
    - **Methane Emissions:** Methane (CH_4), primarily associated with anaerobic conditions in soils, can be reduced by the application of biochar[37].
        - **Methanogenesis Inhibition**: Biochar can reduce methane emissions by improving soil aeration and reducing the anaerobic conditions that favor methanogenesis
        - **Methane Oxidation**: Biochar can enhance the activity of methanotrophic bacteria, which oxidize methane, further reducing CH_4 emissions

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[35] Ullah, M.S., Malekian, R., Randhawa, G.S. *et al.* The potential of biochar incorporation into agricultural soils to promote sustainable agriculture: insights from soil health, crop productivity, greenhouse gas emission mitigation and feasibility perspectives—a critical review. *Rev Environ Sci Biotechnol* **23**, 1105–1130 (2024). https://doi.org/10.1007/s11157-024-09712-4

[36] Liu, Q., Zhang, Y., Liu, B. *et al.* How does biochar influence soil N cycle? A meta-analysis. *Plant Soil* **426**, 211–225 (2018). https://doi.org/10.1007/s11104-018-3619-4

[37] Ullah, M.S., Malekian, R., Randhawa, G.S. *et al.* The potential of biochar incorporation into agricultural soils to promote sustainable agriculture: insights from soil health, crop productivity, greenhouse gas emission mitigation and feasibility perspectives—a critical review. *Rev Environ Sci Biotechnol* **23**, 1105–1130 (2024). https://doi.org/10.1007/s11157-024-09712-4

B.7.3 Demonstration of Additionality: Regulatory Additionality

Please describe and provide evidence for how your Project is regulatorily additional. Refer to Section 2.5.3. "Additionality" of the Isometric Standard and the requirements outlined in the relevant Protocol.

The project operates in the absence of any government incentives or legal requirements for biochar production.

B.8 Durability Assessment

Please confirm that the durability of your chosen sequestration pathway is at least 1000 years, in accordance with the Isometric Standard, and provide justification for how the Project adheres to the durability requirements outlined in the selected Protocol. This may include references to published literature or internal research. You may further expand on the Monitoring approach used to support the claimed Durability assessment in the "Overview of monitoring for durability" section of the next section.

●	I confirm that the durability of carbon removed through this Project is at least 1000 years, in accordance with the Isometric Standard.

The removal pathway chosen by Carboneers and Terrafront ensures the durability of carbon removal for at least 1000 years, demonstrated via a statistically significant number of R_0 measurements.

Ensuring Durability

- Our pyrolysis plant optimizes temperature, residence time, and emissions, enhancing biochar durability and consistency.
- **Inertinite Benchmark (R_0 > 2%)**: Carboneers will routinely measure and report the random reflectance values of the biochar produced in this project[38].
    - New research has introduced a benchmark to measure biochar permanence, showing that biochar can be geologically analogous to million-year-old coal deposits . This benchmark is known as the inertinite ratio. Inertinite is the most stable form of organic carbon in Earth's crust and is considered the ultimate benchmark of organic carbon permanence in the environment[41].
    - Additionally, new scientific evidence published in early 2025 on the longest-running field trials of biochar permanence showed that after 15 years of biochar application, the biochar in soils remained unchanged, confirming the permanent nature of the inertinite share of carbon in

[38] Sanei, H., Rudra, A., Przyswitt, Z.M.M., Kousted, S., Sindlev, M.B., Zheng, X., Nielsen, S.B., Petersen, H.I., 2024. Assessing biochar's permanence: An inertinite benchmark. International Journal of
Coal Geology https://doi.org/10.1016/j.coal.2023.104409

biochar[39].
- Details on the laboratory procedure can be found on the Biochar Production and Storage PDD Appendix.

B.9 Monitoring Plan

Please specify whether this Project will follow the default Monitoring Plan, following the requirements specified in the "Monitoring Plan Requirements" appendix of the relevant Protocol and its associated modules (Option A), or whether a Monitoring Plan will be submitted which may contain additional or modified monitored parameters (Option B).

Additionally, please give an overview of how monitored parameters and/or models will be used to support the assessment of durability. You may also provide any additional information here about how Project monitoring will be conducted.

•	A – I confirm this Project will follow the default Monitoring Plan, following the requirements specified in the "Monitoring Plan Requirements" appendix of the relevant Protocol and its associated modules
•	B – I have submitted a Monitoring Plan, which meets the requirements specified in the "Monitoring Plan Requirements" appendix of the relevant Protocol and its associated modules, and which describes any additional or modified parameters monitored which deviate from the default Monitoring Plan

Overview of how monitored parameters or models will be used to support assessment of durability. If Option B was selected, please give details of how the monitoring plan adds to or differs from the default monitoring requirements outlined in the Protocol:

[Optional] Additional information on Project monitoring:

Reactor Monitoring
Detailed information regarding sensor data, gas leakage, emissions testing, and calibration can be found in the Biochar Production and Storage Annex (x).

Sampling Plan
All information regarding sampling types, frequencies, and characterization can be found in the Biochar Production and Storage Annex (x).

Inventory Analysis and Monitoring Integration
Detailed information regarding the Carboneers Terrafront dMRV application for data tracking can be found in the Monitoring Plan MRV.

Additional information:
Monitoring of Social and Environmental Cobenefits
- Supervisors will conduct farmer surveys and collect soil, water, and air quality measurements at selected farms. Soil types in the project area will be identified, and soil properties will be analyzed on-site using simple tools like water bottles and

[39] Chiaramonti, D., Lotti, G., Vaccari, F. P., & Sanei, H. (2024). Assessment of long-lived Carbon permanence in agricultural soil: Unearthing 15 years-old biochar from long-term field experiment in vineyard. Biomass and Bioenergy, 191, 107484. https://doi.org/10.1016/j.biombioe.2024.107484

cans. This assessment will address the impact of the project on more than 48 Sustainable Development Goals (SDG) sub-targets within the larger SDG framework.

-
- Air quality sensors will be provided to some supervisors to collect data around pyrolysis sites and locations where open field burning previously occurred. This will help quantify the environmental benefits of switching from open field burning to controlled pyrolysis in a closed chamber environment.
- A simple water filtration system using plastic water bottles and biochar as the filtration medium will be tested to assess its potential in providing affordable access to drinking water for households without such access.

Educational and Financial Components:

- For a detailed framework on the SDG sub-targets measured and analyzed by the project, please refer to the following spreadsheet: SDG Framework Spreadsheet
- Every step of the monitoring process to track and evaluate the social and environmental co-benefits of the project will be overseen by Daniel Guarin, Ph.D., the Head of Science at Carboneers. Daniel holds a dual title PhD in soil science and international agriculture and development from the Pennsylvania State University, USA.
- Annual reports will be compiled and provided to inform stakeholders of all advancements and achievements related to the project's environmental and social impacts.

B.10 Data collection and storage

Please describe the data collection and storage approach taken, including:

- *How data is transmitted and collected*
- *How data is stored*
- *Length of time for which records are archived*
- *Backup procedures and strategies for identifying and coping with lost or poor-quality data.*
- *Person(s) / organization(s) responsible for measurement and data collection*

Data Transmission and Collection

- **System**: Data is transmitted and collected through our digital Monitoring, Reporting, and Verification (dMRV) system.
- **Process**: Every day, field supervisors go around and visit sites to capture geotagged and timestamped photographs, along with key measurements. These supervisors also conduct farmer surveys to evaluate the social, economic, and environmental impacts of the project.
- **Verification**: The collected data is first processed and verified by Carboneers and Terrafront before being shared with commercial partners and the certifying body, Isometric.

Data Storage

- **Security**: All data is securely stored with password protection and two-factor authentication, both on servers and in internal databases.
- **Storage Platforms**: Carboneers and Terrafront employ multiple storage solutions to ensure data safety, including Microsoft OneDrive and Google Drive, where the data is stored redundantly across different servers.

Record Archiving Duration

- **Archiving Period**: Records are archived for the entire duration of the project to ensure long-term traceability and compliance with all monitoring requirements.

Backup Procedures and Contingency Strategies

- **Backup Strategy**: Data is backed up on separate servers managed by the team. In addition, the project maintains backups on two different internal servers using the Microsoft and Google suites.
- **Contingency Plans**: In the event of data loss or the discovery of poor-quality data, immediate retrieval is possible from these redundant backups. Regular audits are conducted to identify and rectify any discrepancies or data quality issues.

Responsible Parties

- **Data Collection**: The field supervisors are primarily responsible for the initial data collection, including gathering measurements and photographic evidence.
- **Data Analysis and Verification**: The project team are responsible for the analysis, verification, and final reporting of all collected data.

B.11 Reversals

Please complete a reversal risk assessment for your Project, including consideration of the guidance in the Risk of Reversal Questionnaire below.

Overall risk of reversal (based on risk reversal questionnaire score; please select one):

Very low (0)
Low (1-3)
Medium (4-5)
High (>6)

[Optional] Additional details/assessment of reversal risk mechanisms:

Natural Hazards and Carbon Sink Permanence

- **Wildfires**: The risk of wildfires affecting the permanence of the carbon sink is negligible. Biochar is a recalcitrant form or organic carbon and is not susceptible to combustion or degradation, even in the event of a wildfire.
- **Flooding**: While floods may displace some biochar, leading to a potential loss for the farmers, the carbon removed remains stable. The biochar retains its carbon sink potential even if it is relocated due to flooding.
- **Soil erosion**: As with flooding, soil erosion might displace the biochar, but carbon removal is not affected as the biochar remains stable.
- **Other Natural Hazards**: No other significant natural hazards have been identified in the project area that would compromise the permanence of the carbon stored in the biochar.

Operational Practices and Carbon Removal Permanence

- **Reversal Risk**: The likelihood of operational practices leading to the reversal of carbon removal is extremely low. Biochar, while capable of being used as a burnable material, is unlikely to be repurposed for cooking due to several mitigating factors.
    - **Monitoring and Verification**: Carbon removal is only acknowledged after photographic evidence with GPS, time, and date stamps is provided, verifying the biochar's application to the soil. This rigorous verification process ensures that the biochar remains in its intended use. Also, all stakeholders sign contracts to keep to the rules.
    - **Material Suitability**: Biochar produced from agricultural waste is less suitable for cooking compared to traditional charcoal because it has a lower calorific value and its size prevents it from burning efficiently. This further diminishes the likelihood that it will be repurposed for such use.
    -

The comprehensive assessment indicates that the risk of reversal, whether due to natural hazards or changes in operational practices, is minimal. The project's design, economic incentives, and robust monitoring systems effectively mitigate the potential for reversals, ensuring the long-term permanence of the carbon removed in the biochar.

#	Question	If answered "Yes"	If answered "No"	Response
1	Is a reversal directly observable with a physical or chemical measurement as opposed to a modeled result?	Proceed to questions 2-8	Proceed to questions 7-8	Yes
2	Is the carbon being stored in a closed or impermeable system? (e.g., salt cavern)	Proceed to questions 10-11	Proceed to questions 3-11	No
3	Is the carbon being stored organic?	Add 1 to Risk Score		Yes
4	Does scientific consensus suggest that the carbon storage reservoir has a less than 10,000 year durability?	Add 1 to Risk Score		No[40]
5	Is methane production a Project risk?	Add 1 to Risk Score		No

[40] If H/C ratios are below 0.4 and a R0 of over 2% is achieved, scientific consensus points towards a permanence of over 10,000 years. Sanei, H., Rudra, A., Przyswitt, Z.M.M., Kousted, S., Sindlev, M.B., Zheng, X., Nielsen, S.B. and Petersen, H.I., 2024. Assessing biochar's permanence: An inertinite benchmark. International Journal of Coal Geology, 281, p.104409.

6	Does this approach have a material risk of reversal due to natural disasters including, but not limited to, floods, storms, earthquakes, fires, etc.?	Add 1 to Risk Score		No
7	Does this approach have a material risk of reversal due to human-induced events from outside actors, such as change in farming practices, change in ownership and management of Project sites, or similar?	Add 1 to Risk Score		No
8	[Applicable only for subsurface storage] Is the carbon being stored in the deep subsurface with multiple trapping mechanisms preventing reversals? (e.g., multiple confining layers, CO_2 dissolves or solidifies)	Minus 1 to risk (unless 0)		
9	Is there 10+ years of monitoring and/or lab data demonstrating low project risk?	Minus 1 to risk (unless 0)		No
10	Does this pathway have a documented history of reversals?	Please consider the frequency and severity of previous reversals, and the shared characteristics between documented reversals and the present project. For pathways with no documented history of reversals, add 0 to the Risk Score. For pathways with a history of frequent reversal, add 2 to Risk Score. For pathways with a limited history of reversals, add 1 to Risk Score.		No

11	Is there one or more Project-specific factors that merit a high risk level?	Please consider the number and severity of risks identified. If one low or medium severity risk is identified, add 1 to Risk Score. If multiple risks are identified, or if any high severity risks are identified, add 2 to Risk Score		Low severity risks mostly in methane emissions and feedstock traceability.
Total Risk Score				1

B.12 Uncertainty assessment

Specify how uncertainty is considered, and how removals are to be conservatively estimated, in accordance with Section 2.5.7 "Uncertainty" of the Isometric Standard.

Please specify which option(s) were used in consideration of uncertainty (*one or multiple options*).

- Conservative estimate of input parameters
- Variance propagation
- Monte Carlo Simulations

Please provide a sensitivity analysis.

- I have uploaded a sensitivity analysis in accordance with the guidance in the Isometric Standard

Approach to Uncertainty using Conservative Estimation of Parameters

This project employs a conservative approach to account for uncertainty in biochar production and its associated carbon removals. Biochar production is a relatively straightforward process, but variations in input and output parameters such as feedstock bulk density, biochar chemical composition, or pyrolysis emissions can directly impact the gross volume of biochar produced per plant and the net carbon stored per ton of biochar produced.

Justification for Conservative Estimates:

- **Feedstock bulk density**: We assume a bulk density of 250kg/m3 can be achieved by shredding out biomass to an optimal size for the reactor and may opt for pelletization to increase throughput by weight.

- **Emissions testing**: We assume a 3g/kg CH4 emission factor for our reactor based on previous emission tests conducted on similar reactors produced by the same manufacturer.
- **Transport Distances**: We assume a 25km transport distance for each transported batch of feedstock and biochar although our farms are all located within a 25km radius of the production facility.
- **Electricity consumption**: We aim to have our facility run on 100% solar energy independent of the grid. We therefore exclude the typical emission factor of the nation grid mix per MWh utilized.

Variance propagation:

- **Absolute minimum production boundary:** We model the most conservative values for each impact category within the LCA to identify the minimum production potential and net removal factor per ton of biochart produced.
- **Absolute maximum production boundary:** We model the most optimistic values for each impact category within the LCA to identify the maximum production potential and net removal factor per ton of biochart produced.
- **Average Production Value:** By averaging together the absolute minimum and maximum production quantities and net removal factors per ton of biochar we derive the values which inform our preliminary production case.

Rationale for Conservative Strategy:

- **Inclusivity in Carbon Markets**: Our conservative approach is critical in bridging the gap between industrial biochar production and smallholder farming in the Global South. By applying conservative estimates, we mitigate the risks associated with variability in smallholder contexts, thereby enabling their participation in carbon markets without compromising the integrity of the carbon credits generated.
- **Mitigating Uncertainty**: By consistently applying conservative estimates across key input parameters, we effectively reduce the uncertainty associated with our carbon removal claims. This strategy ensures that our project's impact is not overstated and that our carbon credits are credible and verifiable.

Our conservative estimation strategy, grounded in careful consideration of the variables that influence biochar production, allows us to confidently mitigate uncertainty. This approach supports the credibility of our carbon removal claims, while also empowering smallholder farmers in the Global South to contribute to global carbon removal efforts through sustainable biochar production.

B.13 Use of Models

Please describe your use of models (if any) for quantification, monitoring, and meeting specified Protocol requirements. Describe the specific model and simulations used, with enough detail so that the work could be replicated.

Please provide model validation results to demonstrate model accuracy, and include an assessment of model uncertainty.

No external models were used for quantifying parapaters. Straightforward calculations were used for the LCA and uncertainty assessment and will be continuously updated with empirical data.

B.14 [Applicable to closed systems] Storage site overview
Please describe the storage well / site used, and complete the following information. *This question is only applicable to closed systems. For other pathways, please answer "N/A" or simply delete this question.*
Storage well/site description: N/A
Monitoring overview (*please summarise the current monitoring in place, as required by the relevant permit and in accordance with the protocol monitoring requirements. You may provide more information on individual monitoring parameters in the Project Monitoring Plan):*
Storage well/site location (Address / GPS coordinates):
Regulatory Authority / Jurisdiction: *e.g. US EPA UIC or similar*
Well Class (if applicable):
Permit number:
Permitting authority:

Permit validity start date:
Permit validity end date:
Well/site storage capacity (total):
Well/site storage capacity (used):
Well/site storage capacity (available):

Section C – Duration & Crediting Period

C.1 Project timeline
Please indicate the projected start date of your Project and, if applicable, its expected operational closure date.
Start date of Project: Q1 2025
[Optional] Expected operational closure date of Project:

C.2 Project closure
Please describe the conditions under which the Project will be considered closed, and describe the Project Closure Plan – outlining any post-cessation actions that will be undertaken upon Closure of the Project.
Definition of Project cessation: XXX
Closure Plan: re-purpose plant

C.3 Crediting Period
Please indicate the planned start date and duration of your crediting period. The crediting start date may either be your Project's start date or up to two years prior to design submission, whichever is later. Unless otherwise specified in the relevant Protocol, the maximum crediting period is 5 years.

Start date of crediting period: March 2025
Total length of crediting period: 5 years

D – Environmental and social impacts

D.1 Analysis of environmental and social impacts	
Please provide an assessment of the environmental and social impacts of the Project, in accordance with Section 3.7 "Environmental and Social Impacts" of the Isometric Standard. *For each aspect of the assessment, demonstrate how the risks have been assessed and if applicable, what mitigation plan is in place to prevent them. If some aspects are not applicable to your project, justify how you determined it.* *A full Environmental and/or Social Impact Assessment (EIA and/or SIA) is only required if impacts are considered significant and/or if required by the host jurisdiction.*	
•	[Optional] I have attached a full EIA document.
•	[Optional] I have attached a full SIA document.
•	I acknowledge responsibility for reporting potential environmental and social impacts identified to Isometric and environmental regulators
D.2 Environmental Impacts	
D.2.1 Resource efficiency and pollution prevention, including pollutant emissions to air, pollutant discharges to water, noise and vibration, generation of waste and release of hazardous materials, chemical pesticides and fertilizers.	
•	The risks that are applicable to this Project: **Resource Efficiency and Pollution Prevention** **1. Air Emissions:** • **Risk Assessment**: The environmental risk associated with the Project is the potential methane emissions during biochar production. Methane is a potent greenhouse gas, and its release could undermine the carbon removal benefits of biochar. Carbon monoxide, other light hydrocarbons, and particulates may also be present in the flue gas stream. • **Mitigation Plan**: The project plant will conduct repeated emissions testing to check for all carbon containing flue gas concentrations. Reports on emissions summaries will be written and made available. Process parameters will be adjusted accordingly to minimize negative impacts. **2. Soil Contamination:**

- **Risk Assessment**: There is minimal risk of heavy metal and persistant organic pollutant accumulation in soils with repeated biochar application.
- **Mitigation Plan**: Mitigation plan for soil contamination is explained in the Biochar Production and Storage Appendix

- **Baseline Soil Assessment**

To address the concern of pre-existing heavy metal concentrations exceeding regulatory limits, we propose a comprehensive soil sampling plan to the maximum tillage depth or 30 cm, whichever is deeper, to determine the background concentrations of heavy metals in the region. We will identify the various soil types using the World Reference Base (2006) Soil Groups classification system and develop a stratified sampling strategy to collect representative soil samples from multiple locations within each soil type. Soil samples will be collected doing a random sampling in which a composite sample is made from at least 5 subsamples in the farm chosen. The collected samples will be analyzed for heavy metals by accredited laboratories. The results will be compared to regulatory limits, and background concentrations for each soil type will be calculated. Additionally, we will use reported values in the literature and soil surveys conducted by local authorities to establish a comprehensive value for background heavy metal contamination. If elevated metal concentrations are detected, we will develop specific remediation strategies tailored to the affected areas to mitigate contamination.[41]

3. Water Pollution:

- **Risk Assessment**: There is minimal risk of pollutant discharges to water bodies from the Project. The pyrolysis process is contained, and the use of biochar as a soil amendment has been shown to improve water retention and reduce the leaching of nutrients and chemicals.
- **Mitigation Plan**: To further mitigate any risk, runoff from areas where biochar is applied will be monitored, ensuring that no harmful substances are leached into water systems. The biochar itself will be analyzed to confirm that it does not contain any hazardous materials that could contaminate water sources.
- As with air pollution, biochar is produced on dry days to prevent any surface runoff from carrying biochar away from the site.
- Similar to soil contamination, the biochar will be tested for pollutants that could contaminate waterways. Same safety protocols apply for possible water contamination as reported with soil contamination.

4. Waste Generation:

- **Risk Assessment**: The production process generates minimal waste, primarily in the form of ash. The bags used to measure biochar produced can be used again in future production, ensuring no need for new bags unless production is expected to go up.
- **Mitigation Plan**: Ash produced during pyrolysis will be recycled as a soil amendment, mixed in with the biochar and the manure/ compost required to charge the biochar.

[41] For soil types, we use the soilgrids map to discriminate the different types of soil around the project area and at the farms that will be receiving biochar for agronomic application. This platform provides a soil map at a scale of 250m with detailed classification of soil types for all the world https://soilgrids.org/

	5. Hazardous Materials: • **Risk Assessment**: The Project does not involve the use of hazardous materials, chemical pesticides, or fertilizers. Biochar itself is a non-toxic, stable carbon-rich product. • **Mitigation Plan**: Regular testing will be conducted to ensure that no hazardous materials are present in the biochar or produced during the pyrolysis process.

D.2.2 Biodiversity conservation and sustainable management of living natural resources, including terrestrial & marine biodiversity and ecosystems, protecting habitats of rare & endangered species, avoiding conversion of natural forests, grasslands or wetlands, minimizing soil degradation or erosion, minimizing water consumption and stress.

•	Above risks are applicable to this Project
•	Not applicable to this Project

Terrestrial and Marine Biodiversity & Ecosystems

1. Biodiversity Protection:

- **Risk Assessment**: The Project does not involve activities that would directly harm terrestrial or marine biodiversity. However, any land-use changes or alterations to existing agricultural practices must be carefully managed to avoid unintended impacts on local ecosystems.

- **Mitigation Plan**: The biochar production process is confined to areas already used for agriculture, avoiding the conversion of natural forests, grasslands, or wetlands. This minimizes the risk of disrupting local habitats. Additionally, biochar's role in improving soil health can enhance the biodiversity of agricultural lands by fostering a more balanced and resilient ecosystem.
- The project does not utilize large woody material, which could be repurposed for construction or other uses. This avoids the risk of inadvertently promoting the use of materials that might otherwise be used as fuel or deforestation.
- The biomass stream utilized was not previously employed for essential purposes such as cooking, thereby avoiding the risk of increased deforestation.
- The Project will utilize existing agricultural residues as feedstock, ensuring no additional land is converted for biochar production. This approach safeguards natural forests, grasslands, and wetlands from being repurposed, thus protecting these ecosystems.

2. Soil Degradation and Erosion:

- **Risk Assessment**: Biochar application will likely have positive impacts on soil properties, but in some rare cases, its application can negatively impact soil structure, potentially leading to degradation or erosion if not correctly managed.
- **Mitigation Plan**: The Project focuses on enhancing soil health through biochar application. Biochar improves soil structure, increases aggregate stability, and enhances water retention, all of which contribute to reducing soil degradation and erosion. Constant monitoring by the in-house science team at Carboneers and Terrafront will be conducted to ensure that soil quality continues to improve over time, and best practices will be followed to prevent any negative impacts.

3. Water Consumption and Stress:

- **Risk Assessment**: While the Project itself is not water-intensive, the overall impact on water resources must be considered, particularly in regions where water stress is a concern.
- **Mitigation Plan**: Biochar's ability to retain water in soils reduces the need for frequent irrigation, thereby minimizing water consumption and alleviating stress on local water resources. The Project will monitor soil moisture levels and soil hydraulic conductivity to ensure that biochar application continues to contribute positively to water conservation efforts.

The application of biochar will be restricted to operational farmlands, ensuring no environmental risks beyond those typically associated with farming practices. We will diligently monitor the contaminants present in biochar and track soil health, as well as any potential contaminants that could leach into waterways or the broader ecosystem. This monitoring will enable Carboneers to take appropriate and timely actions should any issues arise.

Sustainable Management of Living Natural Resources
1. Promotion of Sustainable Agriculture:

- The Project contributes to sustainable agriculture by enhancing soil fertility, reducing the need for chemical fertilizers, and improving crop resilience. This supports long-term food security while maintaining the health of natural resources.
- The Project will provide training and resources to farmers to ensure that biochar is applied correctly and sustainably, maximizing its benefits while minimizing any potential negative impacts.

2. Enhancement of Ecosystem Services:

- By improving soil health and increasing biodiversity within agricultural lands, the Project enhances ecosystem services such as carbon removal, water regulation, and habitat provision.
- The Project will continue to monitor the health of ecosystems within the project area, ensuring that biochar application consistently supports and enhances these vital services.

Commitment to Monitoring and Verification
To ensure that the Project remains aligned with biodiversity conservation and sustainable management principles, we will implement a rigorous monitoring and verification system, which includes:

- **Ecological Assessments**: Regular assessments to monitor the impact of biochar production and application on local ecosystems and biodiversity.
- **Soil and Water Monitoring**: Continuous monitoring of soil health, erosion rates, and water use to verify that the Project contributes positively to the sustainable management of natural resources.

D.3 Social Impacts

D.3.1 Labor rights and working conditions, including providing safe & healthy working conditions for employees, fair treatment and equal opportunities in your organization; considerations of prevention of forced labor, child labour or trafficked persons protecting workers employed by third parties.

This is required for all Projects.

•	Above risks are applicable to this Project

Labor Rights and Working Conditions

1. **Safe & Healthy Working Conditions**
    - **Risk Assessment**: The project involves biochar production, which carries potential risks such as exposure to smoke.
    - **Mitigation Plan**: To mitigate these risks, comprehensive training is provided, focusing on safe biochar production techniques, proper use of personal protective equipment (PPE), and safe handling of tools and materials.

2. **Fair Treatment and Equal Opportunities**
    - **Risk Assessment**: The project operates in regions where gender inequality and social hierarchies may present challenges, particularly in empowering women in supervisory roles. The risk lies in potential resistance from male community members or unequal treatment of women in the workforce.
    - **Mitigation Plan**: The project actively promotes gender equality by employing women in key roles such as supervisors and ensuring equal pay for equal work.
    - Additionally, the project includes measures to monitor and promote gender equality, such as tracking the male/female ratio in all positions, decision making power and much more (See Annex B for the Carboneers framework for cobenefits quantification).

3. **Prevention of Forced Labor, Child Labor, or Trafficking**
    - **Risk Assessment**: Operating in regions with varying degrees of regulatory enforcement increases the risk of forced labor, child labor, or human trafficking being present in the workforce, especially among third-party contractors.
    - **Mitigation Plan**: The project has a strict zero-tolerance policy toward forced labor, child labor, and trafficking. All workers are verified for legal age and the right to work. Supervisors are trained to recognize and report any signs of forced labor or trafficking. Regular audits are conducted to ensure compliance with local and international labor standards. The project also works closely with local NGOs to monitor labor conditions and ensure the protection of all workers, including those employed by third-party contractors.

4. **Protection of Workers Employed by Third Parties**
    - **Risk Assessment**: Third-party workers might not always receive the same level of protection as farmers and supervisors, particularly in terms of safety and fair treatment.
    - **Mitigation Plan**: All third-party employees from partner NGOs or our local partners are required to adhere to the same labor standards as the project's direct employees. This includes providing safe working conditions, fair pay, and equal opportunities. Regular compliance checks are conducted to ensure that third-party workers are treated fairly and that any violations are promptly addressed.

D.3.2 Land acquisition and involuntary resettlement in the context of your deployment site selection	
•	Above risks are applicable to this Project
•	Not applicable to this Project

The Project is designed to avoid any need for land acquisition or involuntary resettlement.

Risk Assessment: The Project is implemented on existing agricultural lands and does not require the acquisition of new land. Therefore, there is no risk of displacing communities or individuals, nor of altering existing land use in a way that would necessitate resettlement.

Mitigation Plan: By focusing on the use of agricultural residues for biochar production, the Project ensures that no new land is converted or occupied. This strategy eliminates the possibility of land acquisition or resettlement issues arising from the project's activities. Besides, the amount of biomass per farmer is limited, so we keep it within safe boundaries of sourcing.
The projects grow by incorporating more farmers, instead of growing individual farm operations to discourage land acquisition and involuntary resettlement for biochar production.

The first pyrolysis plant will be located at an old rice mill that has been deserted. .

D.3.3 Environmental and social justice, Indigenous Peoples, Local Communities, cultural heritage, human rights and gender equality (equal opportunities and pay), as it relates specifically to deployment site selection.	
•	Above risks are applicable to this Project
•	Not applicable to this Project

Cultural Heritage and Indigenous Peoples

Our project respects the cultural heritage and rights of Indigenous Peoples. The selection of deployment sites is done in consultation with local communities to avoid disrupting cultural practices or sacred sites. Additionally, we prioritize the use of agricultural waste streams that have no alternative use, ensuring that our feedstock selection does not conflict with local customs or practices.

Social and Environmental Justice:
The project is designed to address social and environmental justice by empowering smallholder communities. By creating economic opportunities through biochar production, we aim to reduce poverty and inequality in rural areas. Additionally, the environmental benefits of biochar, such as improved soil health and reduced emissions, contribute to a healthier and more sustainable environment for these communities.

Mitigation Strategies:
To mitigate potential risks, we have implemented several strategies:

- **Feedstock Selection:** Strict criteria ensure that only waste materials from farming with no alternative use are utilized, avoiding competition with local resources.

- **Training and Capacity Building:** Continuous training for operators, supervisors and farmers ensures that best practices are followed, minimizing environmental risks and maximizing social benefits.
- **Monitoring and Evaluation:** A comprehensive monitoring plan is in place to track environmental and social impacts, including soil health, income levels, and gender equality. This data is collected through surveys and field measurements and verified by independent third parties.

Justification for Non-Applicable Aspects
Certain aspects, such as the displacement of Indigenous Peoples or the destruction of cultural heritage sites, are not applicable to this project. The deployment sites were selected in close consultation with local communities, ensuring that no displacement or disruption occurs. Additionally, our project does not involve large-scale industrial activities that could pose risks to cultural heritage.

D.4 Additional risks

In addition to the above areas of environmental and social impacts, I attest that further risks of potential harm arising from the Project have been assessed, and [please select one below option]:

	A) No such additional risks have been identified
	B) For any such risks identified, appropriate risk mitigations have been put in place and are detailed below.

The project involves several environmental and social risks, each of which has been carefully assessed and addressed through targeted mitigation strategies:

1. We address the gender inequality risk by actively promoting women's inclusion in all roles and excluding communities that resist these principles, with plans to reassess them in future project expansions.
2. The project's deployment sites are selected in close consultation with local communities to avoid disrupting cultural practices or sacred sites.
3. We use only agricultural waste streams with no alternative use and provide ongoing training to ensure sustainable biochar production.

Carboneers and Terrafront are committed to continuously monitoring these risks and adapting our strategies as needed to ensure that the project delivers its intended environmental and social benefits while minimizing potential negative impacts.

D.5 Sustainable Development Impact
Please explain in the below table, where relevant, which Sustainable Development Goals (SDGs) other than SDG13 ("Climate Action") your Project has a positive impact and how this is consistent with the SDG objectives of all jurisdictions in which you operate. If applicable, please include information on any data and parameters monitored before or during the crediting period. *Please see here for a full list and details of all 17 SDGs.* To ensure transparency and credibility in our impact reporting, we have engaged an independent third-party verification process. This process combines rigorous desk reviews with comprehensive field audits to validate that our claimed social and environmental benefits are demonstrably achieved and accurately measured on the ground. This certification provides stakeholders with confidence that our impact claims are backed by objective, verifiable evidence rather than self-reported assessments. In the initial phase, we will focus on achieving verifiable and meaningful impact on 19 SDG subtargets, with measurable impact on 14 out of the 17 SDGs. As the project progresses, we will expand the list of co-benefits to ensure verifiable and certifiable impact on more SDG subtargets positively impacted by the project. A full description of the auditing mechanism and the cobenefits impacted by the project can be found in [redacted]
Please explain whether you assessed the SDG impact of your project prior to this qualitative reasoning. If so, please describe if and which standardized assessment tools and methods you relied on.
Our methods include soil sampling, water sampling, air quality sampling as well as surveys and desk audits of financial flows from the project.

E – Stakeholder Input Process

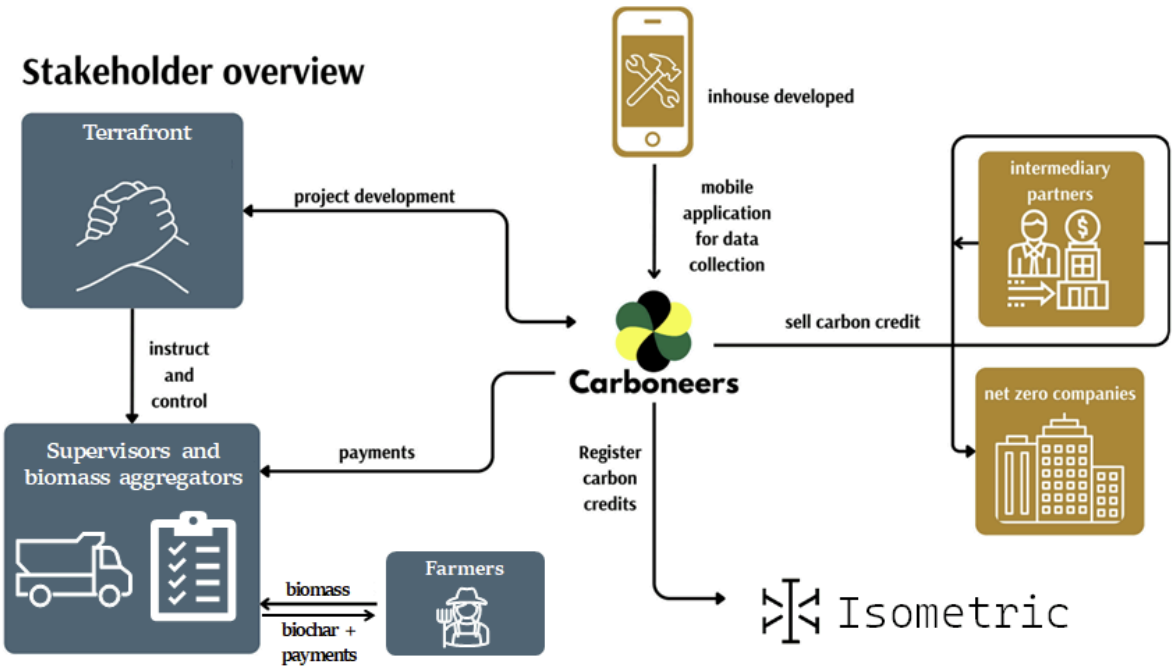
E.1 Stakeholder Input Process Summary
Please provide a description and documentation of how comments by local stakeholders have been invited and compiled, a summary of comments received, and report on how due account was taken of comments received. Refer to Section 3.5 "Stakeholder Input Process" of the Isometric Standard for full requirements.
Stakeholder Engagement and Invitation for Comments Carboneers and TerraFront have implemented a comprehensive stakeholder engagement process to ensure that local communities and other relevant stakeholders are actively involved in the project. Stakeholders were invited to provide comments through multiple channels, including community meetings, focus groups, and one-on-one interviews. Invitations were extended to all relevant stakeholders, including local farmers, community leaders, and NGOs, ensuring broad participation. Meetings are to be held in accessible locations to accommodate all community members, and feedback will be solicited at every stage of the project development. **Compilation and Summary of Stakeholder Comments** So far, no comments have been made to Carboneers regarding the implementation of the project

Incorporating Stakeholder Feedback

The feedback received from stakeholders will be systematically compiled and documented. Key themes that emerge will be identified to signal any particular concerns about potential environmental impacts, the need for fair compensation, and the inclusion of women in project activities.

Continued Engagement

This engagement is continuous and will likely be expanded.
Besides, communities know that we provide even more than income and knowledge over time. Our partners at Terrafront and local NGOs are doing more over history and the future.



E.2 Grievance Mechanism

Please outline the mechanism for stakeholders to voice, process and resolve grievances.

.

Handling of complaints

When a stakeholder wants to file a complaint, this can be done with the supervisor. Partly because the complaint can be concerning the supervisors, we implemented a regular rotation of supervisors. The complaint will be put through to the managers and incorporated into the weekly internal report. Supervisors can also file complaints with managers, the incorporation will again be into the weekly internal report. All complaints will be addressed & noted in person by the senior team involved in the implementation of the program.

Section F – Project Changes

F.1 Summary of changes

Please provide details of the proposed or actual changes to the implementation, operation or monitoring of the project activity description submitted to Isometric.
Project Proponents must determine whether the proposed or actual changes are temporary deviations or permanent changes

If there are temporary changes or deviations which are only relevant to a specific Reporting Period, please note this instead in Section C in the corresponding GHG Statement Report.

(Kindly note that this section may not be applicable during the initial validation. If so, kindly leave the section blank and mention "Section is intentionally left blank.")

No changes have been made to the project

F.2 Impact of changes

Please provide details on the impact of the proposed or actual changes (temporary/permanent) on the following sections of the project:

a) *Additionality*
b) *Applicability of Protocol/ Module*
c) *Quantification of the carbon removals*
d) *Any other (stakeholder consultation, safeguard assessment etc.)*

(Kindly note that this section may not be applicable during the initial validation. If so, kindly leave the section blank and mention "Section is intentionally left blank.")

No changes have been made to the project

F.3 History of changes

Please provide the summary of the changes in the table
(Kindly note that this section may not be applicable during the initial validation. If so, kindly leave the section blank and mention "Section is intentionally left blank.")

Date of change	*Nature of change*	*Impact of change*	*Corresponding version of the PDD*

Document History

Version	Date	Description
v1.7	February 2025	Feedback implementation on each section Reactor specifications doc added Monitoring plan added
v1.6	June 2024	Clarification to explanation that “B.14 Storage site overview” is only applicable to closed systems; revision to require “Regulatory Authority / Jurisdiction” to be provided for this question
v1.5	May 2024	Revision to include section on project changes, guidance to the template and other editorial changes
v1.4	November 2023	Public version (initial adoption)

Annexes

Annex A – Model declaration of honor to cease open field burning

Farmer Declaration Agreement - CEASE OPEN FIELD BURNING

This non-binding agreement is a record of the farmer's written intent to cease open-field burning of the crop waste biomass. The farmer will act in good faith to use the crop waste biomass to produce and use biochar so as to prevent the emissions created from open burning and making biochar.

The information put in the app will be kept confidential and included with the record of biochar production.

By signing the agreement within the app, the farmer understands the sanction of exclusion in the project, when he or she commits open-field burning.

Date:

Location:

Crop:

Supervisor	**Farmer**

Annex B – SDG quantification, monitoring and verification framework:

For the spreadsheet please follow this link. Keep in mind this document is constantly evolving as new data is gathered, new baseline scenarios are assessed and new reports are written.

Attachment. Instructions for completing this form

1. General instructions

1. When completing this form, comply with the “Isometric standard”, the applied protocol and, and any other module applied.

2. If the project proponent, in addition to the monitoring plan referred to in section B.9, develops a document describing how they intend to monitor the project, including the frequency of reporting of monitoring results, and whether they intend to have monitoring results independently verified, attach such document to this form as a separate document.

3. All date formats should be in the format YYYY-MM-DD.

4. [This instruction is only relevant for updates to a PDD following the first approved version]. When documenting any changes that may have occurred to the project activity, prepare two versions of the PDD using this form, one in a clean version and the other version indicating the changes to the previously approved PDD (i.e. the PDD at initial approval, renewal of the crediting period or the last change, whichever is most recent) in track-change. In addition, provide a summary of the changes in Section F.1 of this form.

5. Where a PDD contains information that the project proponent wishes to be treated as confidential/proprietary, submit documentation in two versions:

   (a) One version where all parts containing confidential/proprietary information are made illegible (e.g. by covering those parts with black ink or removing specific details that could reveal sensitive information. However, the redaction should be done in a manner that maintains the minimum level of information required by the template or document guidelines.) so that the version can be made publicly available without displaying confidential/proprietary information;

   (b) A version containing all information that is to be treated as strictly confidential/proprietary by all parties handling this documentation (VVBs and Isometric team requested to consider such documents in support of work for the Board).

6. Any information used to demonstrate additionality, to describe the application of the selected protocol, and to support the environmental and social impact assessment, may not be considered proprietary or confidential. Make any data, values and formulae included in spreadsheets provided accessible and verifiable.

7. Complete this form in English. Prepare all attached documents in English, or if their originals were prepared in other language, provide a full translation of the relevant sections of these documents in English.

8. Complete this form using the same format without modifying its font, headings or logo, and without any other alteration to the form.

9. Do not modify or delete tables and their columns in this form. Add rows of the tables as needed. Add additional appendices as needed.

10. If a section of this form is not applicable, explicitly state that the section is left blank intentionally.

11. Use an internationally recognized format for presentation of values. For example, use digits grouping in thousands and mark a decimal point with a dot (.), not with a comma (,).

12. Complete this form deleting this Attachment

Biochar Production and Storage PDD Appendix

Version 1.0

This PDD template follows the Isometric Standard. Please refer to the Standard for more information on how PDDs are used as part of the procedures of the Isometric Registry.

Key Project Process Data

Pyrolysis reactor technical description of Project activity
Please describe and provide evidence for how your Project has complied with the Reactor Design Requirements for the following: ● *Reactor type and equipment,* ● *Engineering design including sensors,dimensions, process flow diagrams, pressure and temperature measurements, heat transfer or cooling equipment and material selection,* ● *Scale and production rate,* ● *Final products (these can be gas, liquid and biochar),* ● *Flue gas emissions, leakage losses,* ● *Maintenance plan and all further information essential to understanding how carbon removal is achieved by the Project.*
Reactor Type and Equipment: - This pyrolysis reactor design concerns an auger type system in which biomass is fed into a rotating screw that facilitates the upward movement of biomass through the pyrolysis zone. The system has volume limited throughput of 3m3 and a 25-30% biochar yield on biomass (dw). With an estimated 6500 hours of operation per year, each system is expected to produce approximately 1350 tons of biochar per year and excess heat. - To startup the reactor, propane is initially used as a startup fuel. No additional energy sources are required post-startup, as the reactor continues to run on the syngas which is partially recycled to maintain the continuous pyrolysis process. - A lockable air inlet in the pyrolysis reactor ensures controlled air intake volumes and corresponding oxygen levels, and a residence time between 5-7 minutes at 650 degrees ensures the complete pyrolysis of biomass. The biochar is quenched with water to reach a 40% moisture content before dropping into the temporary storage chamber, after which it's weighed inside bags.

- The syngas is appropriately channeled into a combustion chamber and gas cyclone before reaching a heat exchanger which recovers roughly 50% of the available energy in the gas stream. Heat is recycled into a separate drying chamber which will be used to dry high grade agricultural products.

- Auxiliary equipment such as a biomass shredder will be used to ensure feedstock uniformity and increase bulk density, while electric conveyor belts will deliver biomass from the storage pile into the reactor and from the reactor into bags for distribution. The total energy demand of electricity from the auxiliary equipment is approximately 30kWh, the demand for which will be met by a solar installation on the roof of the semi enclosed facility. No other powered external equipment will be used onsite for production as unloading of the biomass and loading of the biochar will be done manually.

Engineering Design Information:

Diagrams and Electrical sheets

- An additional Reactor Details Supplementary Document has been created and shared concerning key engineering diagrams and equipment dimensions along with process flow diagrams, electrical sheets, and component placement information.

Construction considerations:

- A variety of stainless steel types were used in the manufacturing of this pyrolyzer primarily chosen for differences in temperature resistance, corrosion resistance, cost, and availability. SS316Ti steel is used for parts such as the auger screw, screw conveyor center tube, and screw rims which require the highest resilience against temperature.
- Where increased temperature resistance is not paramount, SS310 steel is used. This steel type constitutes roughly 90% of the total steel weight in the installation.
- Refractory bricks and linings are used in the combustion chamber itself where direct flame exposure is most evident. This part of the reactor has no moving parts and benefits from the increased insulating properties of the brinks and lining to keep temperatures high such that hydrocarbons can be fully combusted.

Sensor Types

- A series of type k thermocouples will be used to monitor the temperature at various points in the reactor. Five thermocouples inside the pyrolysis zone will measure the temperature increase between the bottom and top of the pyrolysis zone. Additional thermocouples will be used in the air intakes, and within the pre/post syngas combustion zone. A final thermocouple is placed post heat exchanger so we can monitor the drop in temperature and attribute a heat utilization efficiency for the system.

- A pressure sensor is used within the reactor to monitor steady sub-atmospheric operating conditions at roughly 300mm or 0,4 bar.

Gas Leakage

- This reactor design monitors reactor pressure within the pyrolysis chamber and exhaust gas recirculation (EGR) intake to actively monitor for deviations in standard operational conditions. In normal circumstances, the reactor operates at 0,4 bar. A deviation by more than 50% (0,2 – 0,6 bar) during standard operation would indicate that airflow is escaping or being hindered, at which point the process will be halted and the machinery examined by a specialist.
- Annual inspections for leakage will also be conducted on each unit together with general maintenance.

Calibration

- Annual calibration checks will be conducted for thermocouple and pressure sensor accuracy, unless the manufacturer specifies a more frequent calibration interval is required.
- Calibration records are maintained in an organized database along with relevant certificates. The MRU Prime gas analyzer will specifically act as a certified reference unit for checking thermocouples and pressure sensors within the reactor, as this machine complies with the following standards: EN 15267 (1,2,4) + EN 14793 + EN14181. If deviations >2% are found the sensors will be replaced or sent back to the manufacturer for maintenance.

Emissions testing:

- An in-line gas flow meter and IR spectroscopy equipment (or similar) will not be utilized within this reactor due to the cost and complexity of adding such features within each plant. Instead, an annual emissions test will be carried out with an MGAprime Q portable automatic measuring system and trained operator for each production plant in triplicate. Through these tests, we will verify the exact gas composition and flow rate of the flue gas post combustion. With this data, we will construct and report on the specific emission factors for all carbon-containing gasses with an emphasis on high GWP gasses, namely CH_4.
- Emission factors will be crosschecked between each plant to identify potential underperformering sites such that adjustments can be made to ensure a clean pyrolysis process at each operational plant.

Maintenance Plan:

- Annual plant maintenance will be carried out by a certified partner to ensure structural and mechanical integrity of each equipment type. In the event of sensor failure or identified gas leakage, timely repairs and/or replacements will be made to minimize equipment and production downtime.
- Annual thermocouple replacements will likely be needed, outpacing the recalibration timeframes.

Other:
Chemical reactor model:

- A specific chemical reactor model will not be made for this pyrolysis reactor. Chemical kinetics and continuous gas analysis will not be utilized. A simplified carbon mass balance and process flow will be monitored based on inventory data collected through the Carboneers mobile applications. Extensive empirical data will be gathered throughout the first weeks to optimize the production process, after which data will be crosschecked between plants to ensure consistent operation. All data from the leakage tests

Certification Compliance:
The production facility has been certified under the ISO 9001:2015 the international standard that specifies requirements for an effective quality management system (QMS)[1].

Environmental Safeguards

Pollution Prevention

Please describe and provide evidence for how your Project has complied with Environmental Safeguards for the following specific pollutants:

- *Polycyclic Aromatic Hydrocarbons (PAHs) type and concentration, including mitigation techniques if applicable,*
- *Total Heavy Metals concentration including limits set from local authorities or relevant standards from regulatory body selected,*
- *Other pollutants identified as a risk such as PCBs, Dioxins or Furans*

- Above risks are applicable to this Projects
- Not applicable to this Project

Pollution Prevention

Please provide evidence for how your Project adheres to upper bound limits for the associated pollutants set by World Biochar certificate as stated Required Measurements for the following specific pollutants:

- *Polycyclic Aromatic Hydrocarbons (PAHs) type and concentration,*

[1] This certification demonstrates the ability to consistently provide products and services that meet customer and regulatory requirements. With over one million certifications worldwide, ISO 9001:2015 provides a process-oriented framework for documenting procedures, responsibilities, and resources needed to achieve quality objectives. The 2015 revision emphasizes risk-based thinking and increased leadership requirements to ensure the QMS remains adaptable to changing business environments.

- *Total Heavy Metals concentration,*
- *Other pollutants identified as a risk such as PCBs, Dioxins or Furans*

To prevent any pollution risk, biochar samples will be analyzed for heavy metal concentrations and other organic contaminants and will be subject to WBC upper bound thresholds.

Likewise, soil baseline samples and subsequent soil sampling will be conducted to establish background concentrations of any pollutants in the soil before project implementation and to monitor the effect of biochar on physical and chemical soil properties over time.

We will test the environmental and agronomic impact of the biochar produced and applied to soils to ensure the project complies with all safety standards and protocol requirements. Given the absence of any local regulations, we will be adhering to the World Biochar Certificate Agronomic Thresholds (WBC-Agro)[2].

We will test biochar samples to ensure its safe use in soils and agriculture. Parameters measured will include organic contaminants such as Polycyclic Aromatic Hydrocarbons (16 EPA PAH and 8 EFSA PAF), PCB, and PCDD/F (once per pyrolysis unit for the first production batch, with limits of 0.2 mg kg^{-1} DM for PCB and 20 ng kg^{-1} for PCDD/F), and heavy metals such as Pb, Cd, Cu, Ni, Hg, Zn, Cr, and As. Additionally, we will monitor the agronomic properties of the biochar applied, including Ctot, Corg, H, N, O, S, ash, water content, dry matter, bulk density (at <3mm particle size), WHC, pH, salt content, electrical conductivity of the solid biochar, N, P, K, Mg, Ca, Fe, and TGA.

		WBC-Premium	WBC-Agro	WBC-Material
Heavy metals	Pb	120 g t^{-1} DM	300 g t^{-1} DM	no limit value, only declaration required
Potential toxic	Cd	1,5 g t^{-1} DM	5 g t^{-1} DM	
elements (PTE)	Cu	140 g t^{-1} DM	200 g t^{-1} DM (*)	
	Ni	50 g t^{-1} DM	100 g t^{-1} DM	
	Hg	1 g t^{-1} DM	2 g t^{-1} DM	
	Zn	420 g t^{-1} DM	1000 g t^{-1} DM (*)	
	Cr	100 g t^{-1} DM	200 g t^{-1} DM	
	As	13 g t^{-1} DM	20 g t^{-1} DM	
	Ag, Se	no limit value, only declaration required	no limit value, only declaration required	

WBC -Certification Class		WBC-Premium	WBC-Agro	WBC-Material
Organic contaminents	8 EFSA PAH	1.0 g t^{-1} DM	1.0 g t^{-1} DM	4 g t^{-1} DM
	16 EPA PAH	6.0 g t^{-1} DM	declaration	declaration

The sampling strategy for the biochar samples used for the analysis of contaminants is described in the Sampling Procedure section of this document.

[2] https://www.european-biochar.org/media/doc/2/wbc_1_1.pdf

Adaptive Management Plan, please describe and provide your adaptive management plan including pollutant/metals thresholds, regulatory non - compliance, health risks for relevant stakeholders and workers or farmers.

- Biochar production must adhere to WBC-Agro established pollutant and metals thresholds to ensure environmental safety. Regular monitoring will be conducted to ensure that levels of heavy metals and other contaminants are within a safe level as described in the Pollution Prevention section of this document.

  In the event of regulatory non-compliance, immediate corrective actions will be taken. This includes halting production, identifying the source of non-compliance, and implementing measures to rectify the issue. All incidents of non-compliance will be documented and reported by the plant workers and farm supervisors in charge of supervising biochar application and feedstock collection.

  Health Risks for Stakeholders and Workers

  Biochar production involves potential health risks due to exposure to dust, heavy metals, and other pollutants. To mitigate these risks:

  Personal Protective Equipment (PPE): Workers at the production plant will be provided with full PPE, including gloves, masks, and heat and fire protective clothing

  To reduce dust creation, biochar will be applied in a moist state.

  As described above, both soil and biochar will be periodically screened for pollutants to ensure safety and compliance with WBC-Agro standards for biochar and WHO / USEPA soil pollutants standards.

  Stakeholder Communication

  All stakeholders, including farmers, workers, and local communities, will be informed about the risks associated with biochar production and application.

  This includes risk awareness, and educating stakeholders on the potential health and environmental risks of biochar. This also includes mitigation measures, providing information on how to mitigate and prevent these risks, such as using PPE and handling biochar safely

	If the measured values exceed the maximum allowable limits, we will take a set of mitigation steps. First, we will implement a storage system that prevents any risk to crops while retaining the carbon sequestered by biochar while appropriate mitigation protocols are defined and finalized. The protocols include dilution with compost or any source of material to bring down the overall levels of contaminants. Mixing the polluted biochar with biochar retained from our other biochar projects in India that do not exceed allowable pollutants can be explored. Another alternative is using biochar in concrete/brick blocks (commonly produced in the area) as well as exploring other uses where leachate cannot affect crops. The biochar will be kept in safe storage in concrete floor warehouses until a safe alternative use can be devised with the community surrounding the plant.
•	

Storage in Agricultural Soils

Characterization Requirements (Physical and Chemical)

Analytical Methods and Standards
Please provide a detailed bulleted list of the relevant standards that have been utilized in the biochar characterization - This list does not need to contain data or results and is intended as a reference list for the methods/standards utilized by project proponents - Please refer to Section 3.2 Physical Characteristics and Section 3.3 Chemical Characteristics Where National standards, or recommended standards, have not been used, or a specific Standard Operating Procedure (SOP) has been used in place of a standard please provide additional information on the methods utilized - additional documentation, such as the used SOP, may be required for validation by the project VVB
• The final laboratory used for analysis has not been selected. We have shortlisted a couple of labs that are ISO 17025 certified and follow the standards and SOP for the tests mentioned in the Physical and Chemical characterization sections of this document: The selected laboratory will be an NABL accredited laboratory.. Carboneers can request calibration records and records of certified reference materials used for

calibration from these laboratories to verify the correct analysis of biochar samples, thereby establishing clear quality assurance processes for the data analyzed.

We will request the laboratory to provide a comprehensive document detailing their quality assurance/quality control protocols and their analytical checks, such as duplicate analysis, blanks, and calibration measures.

For all samples submitted to the lab, we will retain double-bagged retention samples in Ziplock bags for up to two years in safe storage in a dry and cool environment.

Physical Characterization

Please provide details of the specific surface analysis (BET) if completed for this project - See section 3.2 Physical Characteristics for more details

A composite sample from the initial batch will be divided into six sub-samples. Each of these six sub-samples will then be analyzed for a specific surface area using (BET), following ISO 9277.

Please provide details of the porosity analysis if completed for this project - See section 3.2 Physical Characteristics for more details

If possible (depending on laboratory capacity), a composite sample from the initial batch will be divided into six sub-samples. Each of these six sub-samples will then be analyzed for porosity using mercury porosimetry and gas adsorption (ISO 15901-2:2022 or equivalent)

Please provide details of the specific external surface area analysis if completed for this project - See section 3.2 Physical Characteristics for more details

If possible (depending on laboratory capacity), a composite sample from the initial batch will be divided into six sub-samples. Each of these six sub-samples will then be analyzed for specific external surface area (Sieving ISO 17892-4:2016 or equivalent)

Chemical Characterization

Please provide details for the carbon content analysis completed for this project - See section 3.3 Chemical Characteristics for more details

Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (6 samples/analyses per batch for the first 30 batches (around 6 samples per month for the first 10 - 12 months) and then 6 samples/analyses every 10 batches for verification (around 6 samples every 9-10 months).

We are measuring carbon content using ASTM D5373, ISO 16948:2015, or a similar equivalent method.

Please provide details for the moisture content analysis completed for this project - See section 3.3 Chemical Characteristics for more details

Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (6 samples/analyses per batch for the first 30 batches (around 6 samples per month for the first 10 - 12 months) and then 6 samples/analyses every 10 batches for verification (around 6 samples every 9-10 months).

We are measuring carbon content using ASTM D1762, ISO 18134 or similar equivalent methods.

Please provide details for the H/C_{org} calculation and analysis completed for this project - See section 3.3 Chemical Characteristics for more details

Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (6 samples/analyses per batch for the first 30 batches (around 6 samples per month for the first 10 - 12 months) and then 6 samples/analyses every 10 batches for verification (around 6 samples every 9-10 months).

Corg and H are calculated using ASTM D5373 or ISO 16948 and inorganic C will be measured in the ash content using ISO 16948.

H/Corg ratios are calculated using molar ratios of hydrogen to carbon.

Please provide details for the O/C_{org} calculation and analysis completed for this project - See section 3.3 Chemical Characteristics for more details

Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (6 samples/analyses per batch for the first 30 batches (around 6 samples per month for the first 10 - 12 months) and then 6 samples/analyses every 10 batches for verification (around 6 samples every 9-10 months).

C org and O are calculated using ASTM D5373 or ISO 16948

H/Corg ratios are calculated using molar ratios of hydrogen to carbon.

Please provide details for the Random Reflectance (Ro) and the frequency distribution analysis including the 2% inertinite benchmark completed for this project - See section 3.3 Chemical Characteristics for more details
Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (6 samples/analyses per batch for the first 30 batches (around 6 samples per month for the first 10 - 12 months) and then 6 samples/analyses every 10 batches for verification (around 6 samples every 9-10 months). Ro will be measured using at least 500 measurements of R_0, calculated at the maceral-level following ISO 7404-5:2009.
Please provide details for the volatile matter analysis completed for this project - See section 3.3 Chemical Characteristics for more details
Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (3 samples/analyses per batch for the first 30 batches (around 3 samples per month for the first 10 - 12 months) and then 3 samples/analyses every 10 batches for verification (around 3 samples every 9-10 months). Volatile content will be measured using TGA, following ASTM D7892
Please provide details for the fixed carbon content analysis completed for this project - See section 3.3 Chemical Characteristics for more details
Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (3 samples/analyses per batch for the first 30 batches (around 3 samples per month for the first 10 - 12 months) and then 3 samples/analyses every 10 batches for verification (around 3 samples every 9-10 months). Fixed C content will be measured using TGA, following ASTM D7892
Please provide details for the ash content analysis completed for this project - See section 3.3 Chemical Characteristics for more details
Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (3 samples/analyses per batch for the first 30 batches (around 3 samples per month for the first 10 - 12 months) and then 3 samples/analyses every 10 batches for verification (around 3 samples every 9-10 months). Ash content is measured using TGA, following ASTM D7892
Please provide details for the PAHs (sum of USEPA 16) analysis if completed for this project - See section 3.3 Chemical Characteristics for more details

Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (3 samples/analyses per batch for the first 30 batches (around 3 samples per month for the first 10 - 12 months) and then 3 samples/analyses every 10 batches for verification (around 3 samples every 9-10 months).

The sum of USEPA16 PAHs will be carried out using ISO 13859

Please provide details for the pH analysis if completed for this project - See section 3.3 Chemical Characteristics for more details

Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (3 samples/analyses per batch for the first 30 batches (around 3 samples per month for the first 10 - 12 months) and then 3 samples/analyses every 10 batches for verification (around 3 samples every 9-10 months).

pH is measured in a slurry using a probe following ISO10390

Please provide details for the Cation Exchange Capacity (CEC) analysis if completed for this project - See section 3.3 Chemical Characteristics for more details

If possible (depending on laboratory capacity) - Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (3 samples/analyses per batch for the first 30 batches (around 3 samples per month for the first 10 - 12 months) and then 3 samples/analyses every 10 batches for verification (around 3 samples every 9-10 months).

CEC is measured using cation extraction and measurement via ICP-MS following ISO 11885

Please provide details for the Bulk Carbon Bonding State analysis if completed for this project - See section 3.3 Chemical Characteristics for more details

If possible (depending on laboratory capacity) - Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (3 samples/analyses per batch for the first 30 batches (around 3 samples per month for the first 10 - 12 months) and then 3 samples/analyses every 10 batches for verification (around 3 samples every 9-10 months).

Bulk Carbon Bonding State is measured using NMR spectroscopy.

Please provide details for the External surface carbon bonding state composition analysis if completed for this project - See section 3.3 Chemical Characteristics for more details
If possible (depending on laboratory capacity) - Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (3 samples/analyses per batch for the first 30 batches (around 3 samples per month for the first 10 - 12 months) and then 3 samples/analyses every 10 batches for verification (around 3 samples every 9-10 months). External surface carbon bonding state composition with be carried out using XPS

Sampling Procedure

Sampling Guidance, Laboratory Requirements, and Data Quality
Please describe and justify the sampling procedure and number of analyses based on the project-specific considerations, following Section 3.4 of the Biochar Storage in Agricultural Soils. ● *Carbon content* Carbon content is measured in 6 samples/analyses per batch for the first 30 batches (around 6 samples per month for the first 10 - 12 months) and then 6 samples/analyses every 10 batches for verification (around 6 samples every 9-10 months). We are measuring carbon content using ASTM D5373, ISO 16948:2015 or a similar equivalent method. ● *Ro measurements* R0 measurements will be conducted in 6 samples/analyses per batch for the first 30 batches (around 6 samples per month for the first 10 - 12 months) and then 6 samples/analyses every 10 batches for verification (around 6 samples every 9-10 months). Ro will be measured using at least 500 measurements of R0, calculated at the maceral-level following ISO 7404-5:2009. ● *Biochar Batch sampling process*

During the batch production process, at least 15 biochar samples will be collected at random intervals to ensure a representative sample of the entire batch. Each sample will be immediately placed into a sealed bag and stored in a cool, dry place to maintain its properties. Once the production batch is complete, all the stored samples collected at different intervals will be gathered and thoroughly mixed in a clean bucket or vessel to create a composite sample. A portion of this composite sample will be double-bagged in a gallon-sized ziplock bag, clearly labeled, and sent to the lab for analysis. The remaining composite samples will be stored in sealed bags and kept in a cool, dry place for at least two years as retention samples for future reference or additional testing.

A detailed information log will be created for every sample from the desired batch, including feedstock, time and date, location (facility), and batch ID. This composite sample will then be sent to the laboratory, where we will instruct them to subdivide the composite 1-gallon sample into three replicates for laboratory analysis. This approach will provide reliable estimations of the mean and standard deviation of the analyzed parameters. A retention sample collected the same way will be placed in safe storage in a cool and dry environment for at least 2 years.

We expect the batch production for paddy straw to last for 24 weeks hence we will collect samples periodically every week to end with at least 24 subsamples that make up the composite sample going to the lab.

Biochar Durability method

Calculation of $F_{durable}$ method

Please provide details on the quantification method selected to calculate $F_{durable}$ see Section 4.1 Quantification of $CO_{2stored}$ for more details

Given we are aiming for 1000-year permanence, we will be adhering to measuring method B (6 samples/analyses per batch for the first 30 batches (around 6 samples per month for the first 10 - 12 months) and then 6 samples/analyses every 10 batches for verification (around 6 samples every 9-10 months). Ro will be measured using at least 500 measurements of R_0, calculated at the maceral-level following ISO 7404-5:2009.

Given this, F durable will be calculated using:

$F\ durable = S - \sqrt{((S*(1-S))/N)}$

Where

- S is the share of samples passing the 2% R_0 benchmark
- N is the number of samples taken per batch

And later used in the total CO2 stored using

$CO2e\ stored = Cbiochar \times Mbiochar \times Fdurable \times (12/44)$

Where

- Cbiochar is the carbon content of the biochar
- Mbiochar is the dry mass of biochar applied.
- Fdurable is the fraction of durable biochar that remains in the soil

Supporting evidence and lab reports will be submitted when they become available

Annual average soil temperature (Applicable for Option 1 only)

Please provide details on the method or approach used for Tsoil calculation used see Section 4.1 Quantification of $CO_{2stored}$ for more details

Environmental Monitoring - Site selection

Field Management Practices

Please describe the field management practices prior to the Project, following Section 4.1.2 of the Biochar Storage in Agricultural Soils .

- *Irrigation schedule and source*
- *Tillage practice*
- *Fertilizer use and composition*
- *Crop type and rotation*

A field management practice survey will be conducted for all farming families (approximately 100 farming families made of 6-8 farmers). This survey will include the Irrigation schedule and source, Tillage practice, Fertilizer use and composition, Crop type, and rotation.

The report will be submitted with findings and an overview of farm management in the project area.

Field Baseline Establishment

Please provide details on baseline soil establishment including relevant measurements and standards used, prior to the Project, if completed following Section 4.1.2 of the Biochar Storage in Agricultural Soils.

- *Soil pH*
- *Soil moisture content*
- *Bulk density/particle size*
- *Soil type and texture*
- *Nutrient Availability*
- *Soil Organic Content*

We are going to be conducting a baseline soil survey, segregating between soil types as determined by the World Reference Base (2006) Soil Groups classification system (https://soilgrids.org/) for the 25km radius surrounding the farm.

For the project area, we will collect at least 15 samples of soil for every soil type as mapped by the World Reference Base (2006) Soil Groups and test for the presence of heavy metals (digestion and ICP-MS analysis) as well as pH (probe in soil slurry), Soil moisture content (ISO 17892), Bulk density (Walkley Black - Dry combustion), Soil type and texture (laser diffraction or pipette analysis), Nutrient availability, and soil organic carbon content.

Document History

Version	Date	Description
v1.0	October 2024	Initial version

Make a copy of this document and submit via the Isometric platform as part of your feedstock validation.

Biomass Feedstock Accounting PDD Appendix

Version 1.1

This Appendix must be completed for each feedstock type and feedstock provider used in this Project.

A1. Feedstock Summary
Please describe your Feedstocks used.
Paddy straw Paddy straw is the dry stalks left behind after the harvesting of rice crops. In India, it is considered an agricultural residue because rice is one of the most widely cultivated crops[1]. The large-scale production of rice results in significant amounts of paddy straw, which farmers often burn to quickly clear fields for the next crop cycle. This practice contributes to severe air pollution and loss of valuable nutrients in the soil. The sheer volume of rice production and the traditional practice of burning make paddy straw a major source of agricultural waste in India[10] Each farming community consists of 16-18 farmers and has approximately 24-30 hectares of land. The project requires approximately 5,500 tons of biomass per year per plant. Each farming community can provide approximately 100 tons of biomass per year per plant. Hence, there will be approximately 100 farming communities for each plant.

A2. Feedstock Hazardous Status
Please describe how you are demonstrating that the feedstock you are using is not hazardous. This may either be done by providing evidence from tests of the feedstock or by providing evidence that the relevant injection permits only allow non-hazardous materials.
Tests on feedstocks will be performed for background levels of contaminants like heavy metals (digestion of samples and analysis of digestate using ICP-MS) , PCBs (High-resolution gas chromatography-mass spectrometry), and dioxins (High-resolution gas chromatography-mass spectrometry).

[1] https://indiadatainsights.com/crop-residue-in-india/

A3. Feedstock Provider Organizations
Please provide a complete list of organizations involved in providing the feedstock, clarifying the organization's role and providing contact information for each. (*Please duplicate the below rows for each additional organization you wish to add)*
Organization 1 ***THE COMMUNITY (around 100 farming families) WILL BE PROVIDING BIOMASS, HENCE NO ORGANIZATION***
Company registration number (*Unique business identification number in your country of registration*):
Organization Name:
Organization Address:
Contact Person:
Contact Email Address:
[Optional] Contact Phone Number:
Organization role in the project:

A4. Potential Market Leakage Impacts Eligibility	
Please select which of the Potential Market Leakage Impact Eligibility Criteria you're using to demonstrate eligibility for this feedstock. *To establish eligibility under market leakage criteria, the Project Proponent must demonstrate either:* ● *The feedstock meets at least one of EC1 through EC4; or* ● *The feedstock meets at least one of EC5 through EC7 and the feedstock meets at least one of EC8 through EC12.*	
[Yes/No]	EC1: Project Proponent does not pay for the feedstock used *No, we do pay for feedstock. Approximately 25 EU per ton of biochar.*
[Yes/No]	EC2: Project proponent is paid a "tipping fee" to remove the feedstock No
[**Yes**/No]	EC3: Project Proponent pays for recovery & replacement activities only

	No
[Yes/No]	EC4: Project Proponent pays to a 3rd party, not entity producing feedstock No
[Yes/No]	EC5: Feedstock is a forest residue No
[Yes/No]	EC6: Feedstock is an agricultural crop residue or an animal waste Yes
[Yes/No]	EC7: Feedstock is a non-marketable industrial waste No
[Yes/No]	EC8: Biomass originates from a regulated forest management project No
[Yes/No]	EC9: Certified forest management activity in increasing carbon stock areas No
[Yes/No]	EC10: Certified forest management activity in exceptional circumstances No
[Yes/No]	EC11: Sustainably sourced agricultural crop residue Yes
[Yes/No]	EC12: Surplus residue with no demonstrated growth of supply No
Demonstrate how your feedstock meets the criteria by providing the required documentation or analysis.	
The price paid, approximately €25 per ton of biomass, compensates farming families for the labor involved in collecting residual biomass. This cost will be documented through invoices signed by both the feedstock supplier (farmer) and the feedstock collector (tractor driver employed by the project). The app used by the tractor drivers requires signatures from both the driver and the farmer each time feedstock is collected, along with the estimated weight of the biomass to ensure fair compensation. The app's backend will display all purchasing records and weights, allowing for tracking of biomass costs and the number of farmers involved	

A5. Counterfactual Storage Eligibility	
Please select which of the Counterfactual Storage Eligibility Criteria you're using to demonstrate eligibility for this feedstock.	
[**Yes**/No]	EC13: Project Proponent must assess the counterfactual fate of the feedstock Yes

[Yes/No]	EC14: Government managed wildfire mitigation or restoration activity No
Demonstrate how your feedstock meets the criteria by providing the required documentation or analysis.	

The counterfactual fate of the feedstock describes how the majority of the harvest residues are burned in the field. However, for the minor fraction that is left to decay in the field, the following emissions are associated with this process:

Straw decomposition occurs mainly during the first 3 years, with the cumulative amount of decomposition reaching 77.0%[2]: In the first and second years, the percentages of organic carbon released were 62.5% and 77.8%, respectively. Additionally, the cumulative percentages of organic carbon release from the straw were 83.2%, 83.7%, and 84.1% after 3, 4, and 5 years of decomposition, respectively[1]. With those rates, we can assume that almost all of the paddy straw residues will decompose and release the biogenic carbon back in the first 15 years.

CO2 Emissions associated to paddy straw decomposition

The primary GHG emitted during the decomposition process is CO2. Based on reference values, the released CO2 from decomposition of paddy straw would be:

1. *Paddy straw composition[3,4]*:
    a. Cellulose: 34%
    b. Hemicellulose: 30%
    c. Lignin: 10%
    d. Total easily decomposable material (cellulose + hemicellulose): 64%
2. *Theoretical maximum CO2 emissions:*
    a. 1 ton paddy straw = 640 kg cellulose + hemicellulose
    b. If fully decomposed: ~939 kg CO2 (640 kg × 44/30, where 44 is the molecular weight of CO2 and 30 is the rough molecular weight of cellulose/hemicellulose molecules[5])
3. *Actual decomposition rate[6]:*
    a. 55.6% decomposition after one year.
    b. That equals 522 kg biogenic CO2 per ton of paddy straw (939 kg × 55.6%)

Adjusting for real-world conditions, considering incomplete decomposition and soil

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[2] Yan, C., Yan, SS., Jia, TY. *et al.* Decomposition characteristics of rice straw returned to the soil in northeast China. *Nutr Cycl Agroecosyst* **114**, 211–224 (2019). https://doi.org/10.1007/s10705-019-09999-8

[3] Kumar, V., Singh, P., Sharma, J. *et al.* Rice straw management through biofuel, biochar, mushroom cultivation, and paper production to overcome environmental pollution in North India. *Waste Dispos. Sustain. Energy* **5**, 483–510 (2023). https://doi.org/10.1007/s42768-023-00152-4

[4] Yan, C., Yan, SS., Jia, TY. *et al.* Decomposition characteristics of rice straw returned to the soil in northeast China. *Nutr Cycl Agroecosyst* **114**, 211–224 (2019). https://doi.org/10.1007/s10705-019-09999-8

[5] Cellulose ($C_6H_{10}O_5$) has a carbon content of 44.4% by weight while Hemicellulose ($C_5H_8O_4$) has a carbon content of 42.1% by weight.

[6] IYan, C., Yan, SS., Jia, TY. *et al.* Decomposition characteristics of rice straw returned to the soil in northeast China. *Nutr Cycl Agroecosyst* **114**, 211–224 (2019). https://doi.org/10.1007/s10705-019-09999-8

incorporation of labile Carbon, we estimate emissions of 400-500 kg of biogenic CO2 per ton in the first year of paddy straw left in the field to decompose.

Paddy Straw Methane (CH4) emissions from decomposition

Assuming reported values for paddy straw:

1. Paddy straw composition[7]:
    a. Cellulose: 34% Hemicellulose: 30% Lignin: 10%
    b. Total easily decomposable material (cellulose + hemicellulose): 64%
2. Methane production potential:
    a. Methane is produced under anaerobic conditions
    b. Assuming 1-5% of decomposed carbon becomes methane (conservative estimate based on typical soil conditions)
3. Carbon content estimation:
    a. Assume ~45% carbon in cellulose and hemicellulose
    b. 1 ton paddy straw = 640 kg cellulose + hemicellulose
    c. Carbon available = 640 kg × 45% = 288 kg
4. First-year decomposition:
    a. 55.6% decomposition in first year[8]
    b. Carbon decomposed = 288 kg × 55.6% = 160.13 kg
5. Methane production estimate:
    a. 1-5% of decomposed carbon becomes methane
    b. Methane carbon = 160.13 kg × (1% to 5%) = 1.60 to 8.01 kg

Converting carbon to methane mass:

- Molecular weight ratio of CH4 to C is 16:12

Methane produced = (1.60 to 8.01 kg) × (16/12) = 2.13 to 10.68 kg CH4 per ton of paddy straw left to decompose

The methane Global Warming Potential for 100 years of this scenario can be calculated using the conversion factor of 27 for non fossil sources in the latest IPCC report[9].

*GWP100 = 2.13 to 10.68 * 27 (kg CO2-eq/ton) = 57.5 to 288 kg CO2eq per 1 ton of paddy straw left to decompose.*

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[7] Kumar, V., Singh, P., Sharma, J. *et al.* Rice straw management through biofuel, biochar, mushroom cultivation, and paper production to overcome environmental pollution in North India. *Waste Dispos. Sustain. Energy* **5**, 483–510 (2023). https://doi.org/10.1007/s42768-023-00152-4

[8] Yan, C., Yan, SS., Jia, TY. *et al.* Decomposition characteristics of rice straw returned to the soil in northeast China. *Nutr Cycl Agroecosyst* **114**, 211–224 (2019). https://doi.org/10.1007/s10705-019-09999-8

[9] Forster, P., T. Storelvmo, K. Armour, W. Collins, J.-L. Dufresne, D. Frame, D.J. Lunt, T. Mauritsen, M.D. Palmer, M. Watanabe, M. Wild, and H. Zhang, 2021: Chapter 7: The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In https://www.ipcc.ch/report/ar6/wg1/ [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 923–1054, doi:10.1017/9781009157896.009.

A6. Dedicated Energy Feedstock Eligibility
This is only applicable to non-forestry feedstocks. *EC15: Feedstock is not used for energy production* *Demonstrate how your feedstock meets the criteria by providing the required documentation or analysis.*
There may be power-to-energy plants in the area; however, confirmation is challenging due to the remoteness of the location and the absence of any available centralized data on energy plants present in the area. According to stakeholders consulted by the project, no such plants are known to exist. Nevertheless, even if present, the small size and minimal capacity of these plants mean that all the feedstock present in the area is not being utilized.

A7. Counterfactual Fate of Feedstock
Please describe and attach any relevant evidence to demonstrate what the most likely counterfactual scenario would be for your feedstock, using guidance outlined in Section 3.2.1 of the Biomass Feedstock Module.
In India, approximately 77% of rice straw is typically burned, with the remaining 9% used for cattle applications (primarily bedding due to its poor nutritional quality), 3% for domestic use as cooking fuel and roofing material, 5% for composting, 2% left in the fields, and 4% for other applications such as brick ovens, pottery, or power plants when available (which our project stakeholders have indicated are not present in the area)[10]. Rice residues (straw and husk) generally have poor nutritional content and are rarely used as animal feed, being more commonly used as bedding for cattle. Prior to the commencement of the project, farming families providing the biomass are identified. Each family is surveyed regarding the crops they cultivate and the types and quantities of biomass available. The survey includes questions about their previous use of biomass, with multiple-choice options and percentage allocations for each use. These uses include open field burning, leaving it to decay, mulching, and animal fodder, among others. Farmers attest to their statements and, as landowners, sign the survey to confirm their responses.

[10] Singh, R., Srivastava, M., & Shukla, A. (2016). Environmental sustainability of bioethanol production from rice straw in India: A review. *Renewable and Sustainable Energy Reviews*, *54*, 202-216. https://doi.org/10.1016/j.rser.2015.10.005

There is no other viable use for the biomass, and due to the high extraction costs and lack of mechanization, farmers are left with no option but to leave it in the open field to burn in preparation for the next season.

Attested statements will be available at the time of the audit with the onground percentage of residual biomass burnt in the field for a more accurate, project specific spread of management of harvest residues prior to the projects intervention.

A8. Replacement Emissions	
Please select which method of replacement emissions accounting you've selected given the nature of your feedstock	
[Yes/No]	Accounting for the feedstock replacement emissions in the LCA
[Yes/No]	Not accounting for replacement emissions due to exemption C1 *(Feedstock has no counterfactual use)*
[Yes/No]	Not accounting for replacement emissions due to exemption C2 *(Feedstock counterfactual use is most likely replaced with a feedstock with no counterfactual use)*
[Yes/No]	Not accounting for replacement emissions due to exemption C3 *(Feedstock has no counterfactual use due to surplus)*
If you selected an exemption above, please demonstrate how your feedstock meets it by providing the required documentation or analysis.	

Document History

Version	Date	Description
v1.0	November 2023	Initial version
v1.1	December 2024	Updates to ECs as part of the v1.2 Feedstock accounting module