DARK EARTH CARBON

Sifuri Halisi Project

Business plan and scoping document

Mafinga, Tanzania

March 2023

Executive Summary

- The purpose of Dark Earth Carbon Ltd.s' (DEC) Sifuri Halisi Project is to drawdown carbon from the atmosphere and stably store it to help reverse the effects of climate change. Given its long permanence, DEC views biochar as an excellent vehicle for this work.
- The Sifuri Halisi Project will sequester 5,439 tCO_2e per annum through biochar. This scoping document outlines the operational plans as well as gives an initial analysis of overall greenhouse gas reduction.
- Located in Mafinga, Tanzania. The project will use waste wood and thinnings from the timber industry which is currently being burnt or biodegrading.
- Disaggregation of the biochar will help improve soil fertility in the area, increasing yields for smallholder farmers, improving degraded forests, and increasing local agricultural production.

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Project Introduction

Dark Earth Carbon ("DEC") will install a biochar reactor with a feedstock capacity of 1T per hour in Mafinga, Tanzania in the heart of the country's timber industry. Through in place agreements with sustainable forestry organisations in the region, DEC will have access to over 100,000 tons of waste biomass per annum from thinnings and off-cuts. As per a 2018 study done by the Private Forestry Program, the Tanzanian wood industry produces large amounts of waste (see figure below). In 2015 alone, residues and waste generated by the industry amounted to almost 1,000,000 tons. Thus, there is significant room for expansion into more reactors once any logistical and operational issues with the first machine are resolved. This first reactor site and associated activities will be known as the "Sifuri Halisi Project"[1].

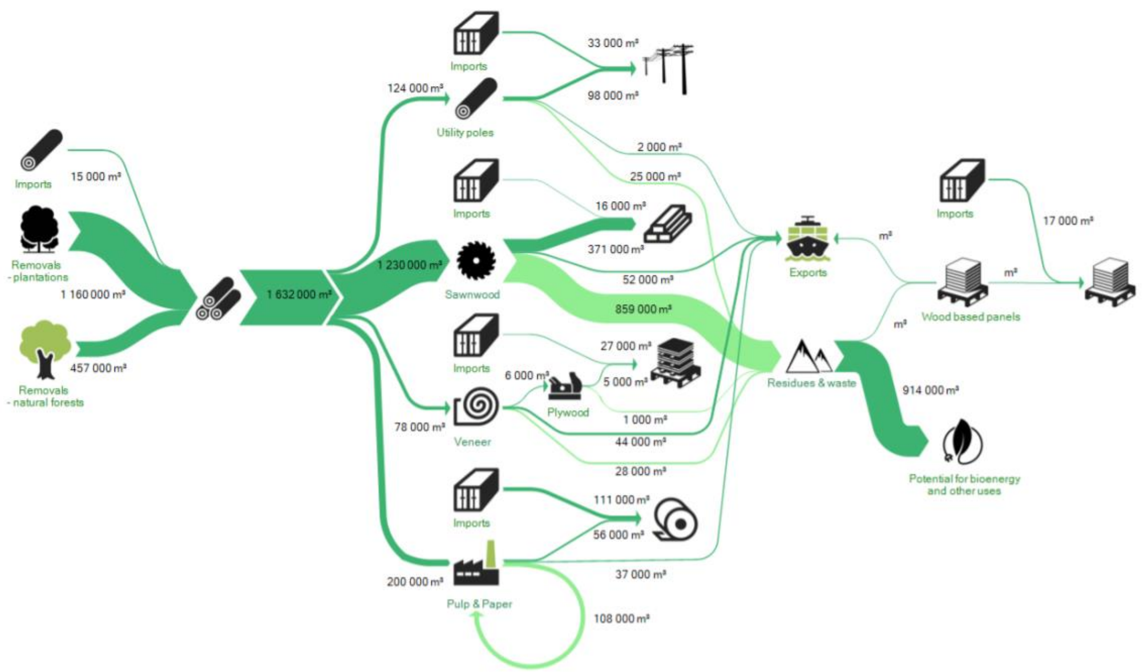


Figure 1: Waste timber flows from the Tanzanian Forestry Industry[2]

The resultant biochar will be put towards a range of uses through various end users. DEC will work with partners in different industries to build the use cases for biochar in Tanzania. Initially this work will focus on agricultural uses.

[1] "Sifuri Halisi" is Swahili for "Net Zero".

[2] From "PRIVATE FORESTRY PROGRAMME Investment Opportunities in the Tanzanian Forest Industry and Bioenergy Sectors, Cluster Analysis. April 2018"

The purpose of DEC's work is to drawdown carbon from the atmosphere and stably store it to help reverse the effects of climate change. Given its long permanence, DEC views biochar as an excellent vehicle for this work. Additionally, by creating (potentially) valued use cases across a range of industries, DEC hopes to catalyse biochar production leading to more carbon drawdown and a virtuous cycle of investment and climate restoration.

DEC views Tanzania as an ideal location for their work for several reasons. On the feedstock sourcing side of the project, as a tropical country, biomass growth rates are higher than seen in temperate zones. As Tanzania is the major exporter of low-grade forestry products (pole, boards, planks etc) to the growing economies of the East Africa region, the supply of waste material (thinnings etc) is currently very high and expected to significantly expand. High carbon content feedstock will be available at a low price for a significant number of years.

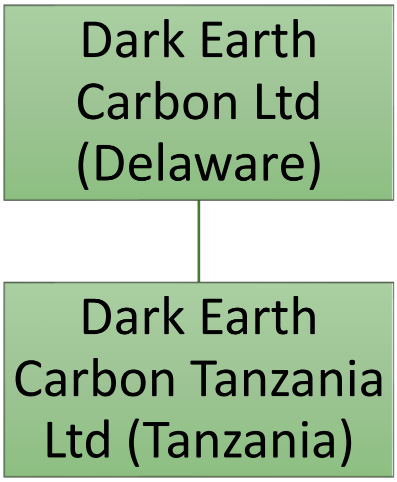
In terms of productive uses of the produced biochar, the long-term upside to working in Tanzania is significant. The poverty alleviation potential from marginal improvements to agricultural returns are enormous. Over 70% of people live below the $1.90 per day poverty line (above 80% in rural areas) and over 65% of the population are dependent on the agricultural sector for their livelihoods. Tanzanian soils are in the main quite acidic meaning the impact of a biochar soil amendment will significant. In this context – low incomes, high dependence on agriculture, high impact potential for biochar-based soil amendments – a high quality and constant supply of biochar has the potential to improve the lives of many 1000s of people.

One in every two people born between 2022 and 2050 will be born in Sub-Saharan Africa. The demographic bugle underway across Africa poses challenges across many dimensions; among them rapid urbanisation. The need for roads, building, homes and build infrastructure in African is great and increasing. Dar es Salaam, the commercial capital of Tanzania, is among the fastest growing cities in the world and will be among the 10 largest in the world by 2050. Here again, the potential for biochar to make a meaningful impact in the emissions caused by the construction industry is large. Establishing a significant biochar industry in Tanzania will lead to locally developed solutions servicing the construction industry which have been tested and tailored to local conditions.

Tanzania is a low cost work environment with relative geographical proximity to machinery suppliers from both China and Europe. DEC's management team has significant operational experience in Tanzania and so is familiar with the regulatory frameworks in place. Finally, Tanzania is a politically stable country with a history of macroeconomic policies that are conducive to medium/long term investments.

Company Structure

The company has been structured as per diagram below to assist in long term capital raising. Carbon credits will be produced and sold from the Tanzanian entity with debt/equity being brought in from the Delaware entity due to Tanzanian regulations. Ownership and control of the Tanzanian entity being currently split by the Delaware entity and Amar Shanghavi as he is a Tanzanian national and this assisted in expediting the registrations. It is planned to issue shares to the Delaware entity such that Amar Shanghavi shareholding becomes negligible.



Funds will be brought into DEC Tz as a combination of debt and equity. This is partly due to Tanzanian regulations only allowing debt to come in from foreign providers at 16-17% p.a. interest rates (which are correlated to the current estimated WACC for Tanzania). This debt will be registered with the Bank of Tanzania. The amount of debt to be brought on as equity vs debt will be calculated to make the total repayment amount equal to the terms of the debt coming in from Atmosfair. This would be approximately 135,000 Eur of debt and 115,000 Eur of equity coming in from the Delaware entity from the Atmosfair loan.

Site Location

For the Sifuri Halisi Project, DEC has an in place five-year rental agreement (with an option to buy) for a 20 acre site in Mafinga, Tanzania. This site is situated on the main highway to Dar es Salaam. Mafinga is located in the heart of the Tanzanian forestry industry and is also in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) which is a region of agricultural significance as designated by the Tanzanian government.

The layout of the Mafinga Sifuri Halisi site is shown in the figure below which shows where the initial facilities are to be based. The weight bridge shown will likely be installed at a later date to help with the volumes that we will be using.

Figure 2: Sifuri Halisi Project Site

Management Team

Arno Rohwedder: Arno is an operations specialist (multi-nationals and his own startups) for twelve years with nine years in sub-Saharan Africa. Previously working as an oil and gas engineer he has lived and worked around the world. He has been based in Tanzania for the last seven years building companies and has a first-hand experience across a range of industries relevant to DEC's work.

Matthieu Tourne: Matthieu is a technologist with twelve years of experience taking startups off the ground, by leveraging data and software. He combines the power of software and data to solve real world problem – and there is none more pressing than climate change. With verification of carbon claims so important and the power of emerging technologies to deliver an unprecedent level of trust, Matthieu and DEC are well placed to be at the forefront of these trends.

Alex Chetkovich: Alex has ten years' experience in smallholder Tanzanian agriculture with a successful track record of in-country company building. From a natural resource management background Alex moved to Tanzania in 2012 after completing a Master's in International Development at the University of Edinburgh. He has started and grown successful ventures in Tanzania; both with a non-profit and commercial enterprises.

Amar Shanghavi, PhD: Ten+ years of experience in public and private sector with specific expertise in the forestry and manufacturing processes. After completing his PhD at the London School of Economics investigating trade and infrastructure projects and stints at the IMF, Amar returned to his native Tanzania. Placing smallholder farmers at the heart of his ventures, he has deep connections and understanding of the forestry industry in Tanzania and East Africa.

Business Rationale

The Sifuri Halisi pilot project is being conducted as a sustainable business, this means that it should be profitable and be able run without continual injection of capital. The business income is from two primary streams (carbon credits and biochar sales) and one secondary (waste heat). These will be described in more detail in terms of their customers, pricing/profitability, and distribution.

Carbon Credits

As discussed throughout this document there is a large carbon removal aspect to the project and this will be one of the primary incomes for the company. In recent years carbon removals have become understood to be a large requirement to the decarbonisation of society with Biochar being one of the primary decarbonisation methods that will contribute to removing CO_2 from the atmosphere.

Customers and distribution

The initial customer for our carbon credits will be Atmosfair who through the CSPA we are going to be selling the credits at 80 Euro/tCO_2e. Distribution and marketing of the credits will be taken care of from their side which de-risks the project dramatically on this side.

Costing and Profitability

We estimate that the cost of producing one tonne of biochar to be in the range of 60-100 USD/tonne (as the cost of goods sold, not including overheads) dependent on a few factors which will be proven out in the model. We expect this number to come down over the longer term also as we gain efficiencies in our production. Each tonne of biochar is equivalent to 2.01 (within our current methodology estimates), and so our COGS per tCO_2e is approximately 30-50 Euro/tonne. With the price of carbon credits at 80 Euro/tCO_2e this gives us a buffer on profitability in case the costs come out to be higher than we expect or the output lower.

Biochar

The Biochar itself is potentially extremely valuable as a soil amendment product. DEC anticipates that through an R+D process of working through the best methods of formulation and application the demand for the product will be very high. There is a lot of research which has indicated that biochar works to increase yields of agricultural crops whilst at the same time reducing the need for chemical fertilizer. It is planned to formulate the biochar as a “Soil builder” which will be applied either at planting or broad acre. The mechanisms involved are beyond the scope of this document, however if further information is needed this can be provided.

Customers and distribution

The customers for our Biochar Soil Builder will primarily be farmers in the Southern highlands area. This area is one of the most productive farming areas of the country with both smallholder farmers and commercial farming operations. To begin with we will be conducting numerous field trials to test the product with different formulations and application methods to see where the best use of the biochar lies, this will help also to ascribe value to the product as calculations can then be made related to the additional yield and reduced fertilizer usage. We anticipate that it will initially be tree crops and cash crops that will be the primary focus areas as the increased yield will justify the extra costs for the farmer quite easily. Longer term however, economic models which will work for broad acre crops will be explored to see how biochar can work for these types of applications.

We will have a traceability system which will allow us to identify the end biochar usage to fit in with the requirements of our carbon credit verification. This means our distribution system will trace the biochar until the point it is purchased or collected by the end user. The emissions for this have been considered when conducting the carbon accounting.

Marketing and educational efforts must also be done to ensure the farmer has knowledge of biochar. A basic survey which was conducted has indicated some current knowledge of biochar being used as a soil amendment by both smallholder and commercial farmers. The idea of soil carbon is also well established, so our marketing will need to be targeted through these routes.

Costing and Profitability

As mentioned above, our estimated cost of biochar will be approximately 60-100 USD per tonne, much of this cost however will be ascribed to the carbon removals being sold. Once we have better numbers ascribing value to the biochar (product) vs the carbon removal credits will be done through standard accounting practices. The way that we are looking at the biochar revenue however, is as a risk reduction on the overall profitability of the project; longer term we will price the additional value it is producing for the end farmer once there is traction from the market.

Although we don't expect these prices in Tanzania, it has been seen in more advanced markets that biochar is sold at ~500 Euro/tonne, which is likely indicative of the value it is providing to the customer, this pricing is aspirational, but unlikely.

For our soil builder product, we will look at initial pricing of around 50-100 USD/tonne, and then raise it gradually to around 200 USD/tonne once we have proven formulations and people have a better understanding of the product in the marketplace. This would be benchmarked against things like urea (~1000 USD/tonne currently), chicken manure (~50-200 USD/tonne), lime (~200 USD/tonne) and others. Again, it must be stressed that we need to prove the benefits of the product as a soil amendment before a proper price can be determined.

Heat

Heat as a by-product will also be explored for its economic potential. This, however, won't be finalised in the initial 6 months of the project so we can focus more on the biochar operations and research will be done to a greater extent once we have started operations. Our current initial exploration is focused on using the waste heat for drying wood which would reduce the weight of the wood and thus the transportation costs. Alternatively, as we scale up there would be large potential for using the waste heat in electricity production which would then be sold to Tanesco (the national electricity provider) for a feed in tariff. On top of this there would be potential for agribusinesses to utilise the waste heat in their processing, however, to do this, we would need agribusiness to set up a facility in an adjoining plot.

Timing of additional Heat units

Once we have the pyrolysis reactor commissioned we will be investigating the ability to utilise the waste heat. This would need to take into account:

- Quality of heat available,
- Amount of heat available,
- Interface between the reactor and heat exchanging mechanism, and,
- Further assessment on economic potential of the different heat sales options.

However, as per section 8.4 of the "European Biochar Certificate - Guidelines for a Sustainable Production of Biochar" document, drying biomass is an acceptable usage of the waste heat produced by the kiln. It is also indicated that we have a 3 year transitional period to ensure that at least 70% of the waste heat is utilised by these processes.

Customers and distribution

Depending on the final usage of the waste heat, this would determine how our customers and distribution would be formed. If selling as electricity, then it would be through a feed-in tariff with Tanesco. If as drying services, then we would set up a drying kiln at our facility where people would be able to pay to dry their wood as an additional service. The heat for drying has been discussed with various smaller wood operators in the area and they have indicated that this is a service that they would be willing to pay for.

Costing and Profitability

Costing will be based on what the price demand would be and would need to ensure it pays off the capex/depreciation on the additional equipment needed to implement the additional product line. A deeper feasibility study will be needed for the electricity production as this would need to go through many regulatory hurdles prior to commencing.

Project Boundaries

The Sifuri Halisi Project incorporates three elements for emission analysis:

1. Baseline and biomass feedstock supply
2. Processing and production
3. Post-production and application

Excluded from this scope are any emissions related to the growing of feedstock as all feedstock used is waste and would otherwise have been combusted or decomposed. In this initial project scoping document, the baseline has been conservatively estimated as zero. A high technology pyrolysis reactor is being installed as well as a wood drying kiln to utilise the excess heat from the biochar production. The resultant biochar will, in the main, be mixed with different additives (fertilisers, manure etc) in a mechanical rotary mixer to create a final Soil Builder product. Emissions from these ancillary elements are within the project boundary.

Leakage from these three elements is also calculated however any emissions caused by the end user after they take possession of the biochar (for example in construction) are not part of either leakage nor within the project boundaries. Additionally, any emissions due to the wood drying activity (transport of lumber to/from the facility that is not feedstock, carbon embedded in timber construction, other elements of the drying process etc) are excluded from the project boundary.

Baseline and Biomass Feedstock Supply

DEC will make use of waste biomass resources from sustainability grown crops to produce biochar. The biomass is renewable because the project will only make use of waste biomass from forest management (thinning, cuttings etc.) or secondary waste biomass.

DEC will initially source waste from three types of sources.

1. Smallholder plantations
2. Tanzania Forestry Services (TFS) plantations
3. Timber processes that source raw material from the above two plantations types

The third source mentioned above is 'secondary waste biomass' which we define as fragments of products or finished products of a manufacturing process that has converted a virgin wood resource into a commodity of real economic value.

DEC is also committed to source the biomass from plantations that adhere to our sustainability principals. This aims to make sure that the project participants work together with local stakeholders that are willing to be sustainable from a social, environmental, and economic point of view.

All biomass processed by DEC must be traceable to it's source. To do this our field team will register suppliers and record volumes of waste sourced from each location. These suppliers will be audited for compliance to our sustainability standards. If a supplier fails an audit or investigation, DEC will not source biomass from the supplier.

Waste disposal is currently an expense that many plantations and processors incur. By providing a waste disposal service, DEC alleviates a pain point which gives us a degree of leverage over compliance with sustainability goals. Additionally by collecting waste we will be providing an important service to the community, the local government in its waste management handling and overall reducing the fire risk[3] [4].

To help support the transition to a more sustainable forestry sector in Tanzania, DEC will conduct biodiversity and sustainability trainings with the smallholders and Tree Growers Associations (TGAs) from which we source our biomass feedstock.

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[3] See: "Drivers, trends and management of forest plantation fires in Tanzania" Andrew, 2020
[4] See: "Assessment of Wildfires in Tanzania Forest Plantations: A Case of Sao Hill in Mufindi District" Mugina and Wawa, 2020

The training program will be developed in conjunction with the Forestry and Wood Industries Training Centre in Mafinga and involve extension officers from the PFP2 program who are already well versed with forestry issues and have a long term relationship with the TGAs. After the initial training series on biodiversity at the various TGAs with whom we will engage in purchase agreements, ongoing refresher trainings will also be used to review/adapt/develop appropriate training materials based on feedback.

The objectives of the training are:

- Demonstrate the importance of biodiversity
- Educate on the best planting practices including:
  - Site preparation
  - Protection of biodiversity sites, wetland areas, water sources, burial, archaeological, cultural and spiritual sites.
  - Planting does not occur within 60m of a waterbody
- Post-planting maintenance phase to promote ground cover in between stems
- Managing crop species and non-target species competition through weeding between planted stems.
- Species selection
  - Identification of fast growing indigenous timber species
  - Inclusion of fast growing indigenous timber species in the plantation
- Fire risk and management

These training concepts, materials, schedule, and all related documentation will be shared with Atmosfair as they are developed over the initial implementation period of the Sifuri Halisi project.

Processing and Production

Please note that all CO_2 calculations are initial calculations and though they are in the correct order of magnitude, they have been updated with final calculations defined in the PDD.

DEC is installing a reactor at the Sifuri Halisi Project site with a feedstock throughput capacity of 1T/hr. The reactor technical specifications, including an emission test carried out by SGS, can be found in Appendix 0 and 0. The reactor is forecast to run 7,884 hours[5] per year with a biomass throughput of 7,884 Tonnes[6] and a biochar output of 2,759 Tonnes[7].

[5] From tab “Assumptions” in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx”
[6] From tab “Assumptions” in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx”
[7] From tab “Assumptions” in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx”

DEC biomass feedstock comes from Pine and Eucalyptus forestry waste. Based on the specifications of our reactor and the existing scientific papers on biochar from these materials, we expect our char to have the following key characteristics:

Organic Carbon %:	> 75%
H/C ratio:	< 0.4
O/C ratio:	< 0.4

Laboratory analyses will be carried out to determine exact parameters and ensuring our raw biochar product meets the required standards and thresholds. These analyses will form part of DEC's Quality Assurance System.

Fixed carbon

To calculate the amount of fixed carbon produced by the Sifuri Halisi Project in a year, the following equation is used:

$$CC_{y,t} = M_{y,t} * F_{cp} * PR_{de}$$

Where:

$CC_{y,t}$	Fixed carbon content (C)
$M_{y,t}$	Mass of biochar produced (all biochar is applied with an end-user, see section below) in tonnes
F_{cp}	Organic carbon content (%)
PR_{de}	Pre-set soil permanence factor

Based off the Sifuri Halisi Project's annual production as well as the estimated organic carbon content of the biochar, it is estimated that a fixed carbon content of 1,531 tonnes of Carbon[8] will be produced. This number will be verified through Quality Assurance and standard monitoring procedures during operation.

Pre-processing - chipping

As discussed in Chapter 0 above, the feedstock for this reactor is waste biomass from sustainable timber plantations in the nearby regions. These offcuts and thinning will be fed through chipping machines. This constitutes the sum total of 'pre-processing' of the waste biomass. For the purposes of this scoping document, it will be assumed that all biomass will need to be chipped however this is unlikely the case in practice. Actual data on chipper run time will be collected as per DEC's Quality

[8] From tab "ERp (eq4)" in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx"

Assurance System, however estimated values have been calculated. To calculate emissions from pre-processing of the biomass, the following equation is used:

$$P_{ED,y} = SUMi(Q_{i,y,energy} * COEF_{i,y})$$

Where:

$P_{ED,y}$	Emissions due to feedstock pre-treatment (tCO_2e)
$Q_{i,y,energy}$	Amount of energy used
$COEF_{i,y}$	CO_2 emissions coefficient of type of energy used

DEC's chipper will run from grid power at the Sifuri Halisi Project site. To pass 100% of the biomass feedstock through this chipper prior to pyrolysing will emit 5.1 tCO_2e[9].

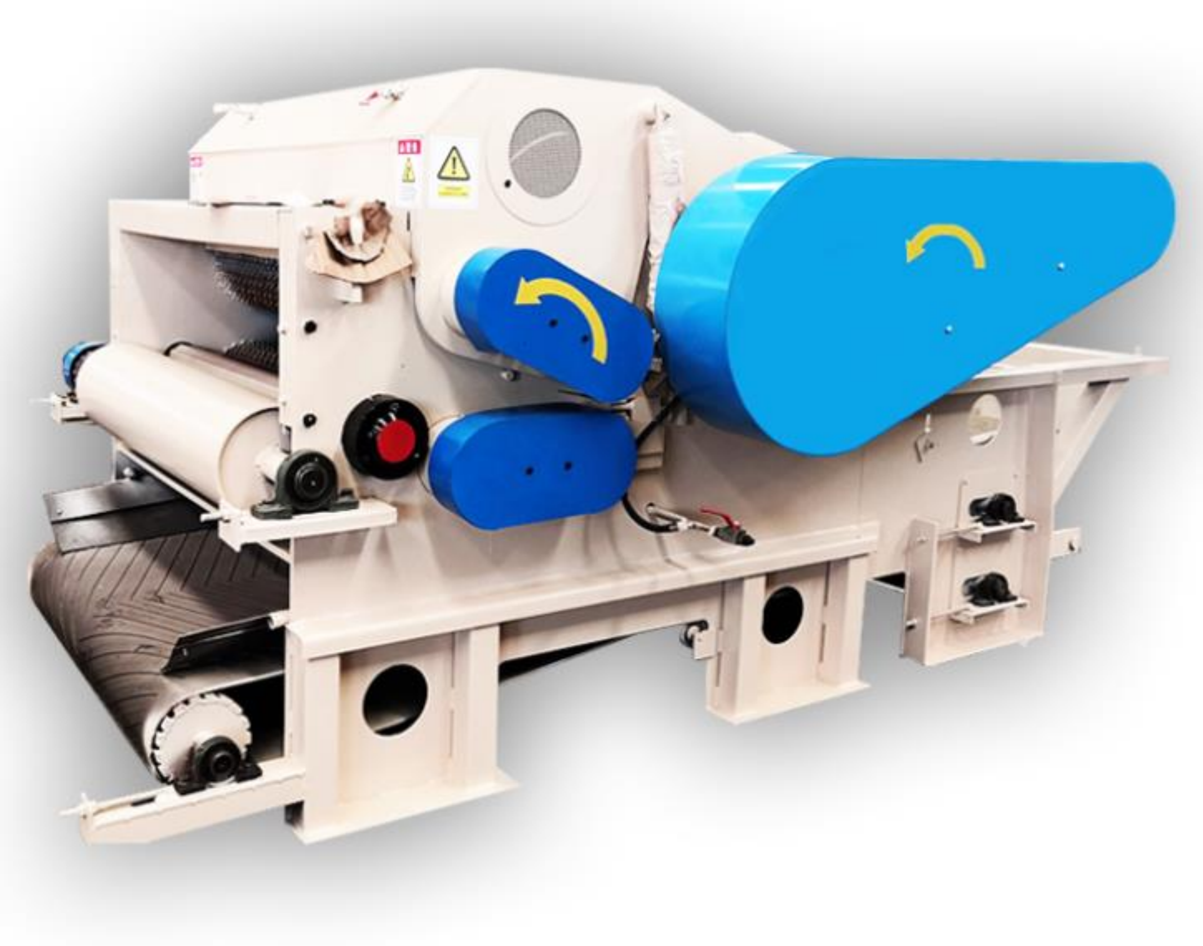

Figure 3: Wood chipper for use in getting feedstock to appropriate size for pyrolysis

[9] From tab "Ped,y (eq6)" in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx"

Pre-processing - drying

The chipped biomass will also need to be dried to a suitable moisture content for pyrolysis. The requirement for input into the reactor is 15% moisture content. Estimated moisture content of the input material upon collection is 35-45% moisture content. A rotary dryer unit will be located prior to the pyrolysis reactor and will utilise the waste heat from the pyrolysis reaction.

If additional drying is required prior to the rotary dryer, then this will be done in a kiln dryer which will also be heated using the waste heat from the pyrolysis reactor. No additional energy input is expected to be required for this step.

Pyrolysis reactor

DEC's reactor requires a gas injection to heat the combustion chamber and an electric motor to turn the central rotors as well as to run the other electrical systems involved during the pyrolysis process. The external emissions associated with this energy usage have been calculated below.

DEC estimates that there will be 24 machine restarts annually. Biogas emissions from the pyrolysis are captured and combusted to not release into the atmosphere. The heat generated by the pyrolysis process is utilised for wood and biomass drying. This drying facility is for both DEC's own biomass feedstock and as a service to the surrounding lumber industry.

The emissions generated by gas pre-heating the reaction chamber and from grid power to turn the rotor and run the machine are calculated using the following equation for each process:

$$P_{EC,y} = SUMi(Q_{i,y,energy} * COEF_{i,y})$$

Where:

$P_{EC,y}$	Emissions due to annual reactor restarts (tCO_2e)
$Q_{i,y,energy}$	Amount of energy used
$COEF_{i,y}$	CO_2 emissions coefficient of type of energy used

To pyrolyse the annual biomass feedstock at the Sifuri Halisi Project site will emit 153 tCO2e[10] through chamber heating with gas and electric motor operations.

Emissions from the combination of the processing steps (chipping and pyrolysis) multiplied by the proportion of biochar that goes to an end-user (see below for more explanation on this process) gives the emission at production stage. This value is calculated through the following equation:

$$PE_{PS,y} = SUM((P_{ED,y} + P_{EC,y}) * (M_{y,t} / M_{x,t})$$

Where:

$PE_{PS,y}$ Production stage total emissions (tCO_2e)
$P_{ED,y}$ Pre-treatment emissions (chipping)
$P_{EC,y}$ Additional energy emissions (chamber heating, rotor operation, other electricity usage)
$M_{y,t}$ Biochar utilised by end-user
$M_{x,t}$ Annual biochar production

Across the two processing steps; chipping and pyrolysis, DEC's Sifuri Halisi Project emits 158 tCO2e11.

Using this number (PEPS) and the total production number, the total greenhouse gas removals from the production stage can be calculated using the following formula:

$$ER_{PS,y} = SUM(CC_{y,t} * (44/12))- PE_{PS}$$

Where:

$ER_{PS,y}$ Total greenhouse gas removals from the production stage
$CC_{y,t}$ Fixed carbon content (tCO_2e)
PE_{PS} Total emissions due to all stages of production

The biochar produced minus the emissions generated through the process result in removals of 5,457 tCO_2e[12] per annum.

[10] From tab "Pec,y (eq7)" in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx"
[11] From tab "Peps (eq5)" in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx"
[12] From tab "ERp (eq3)" in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx"

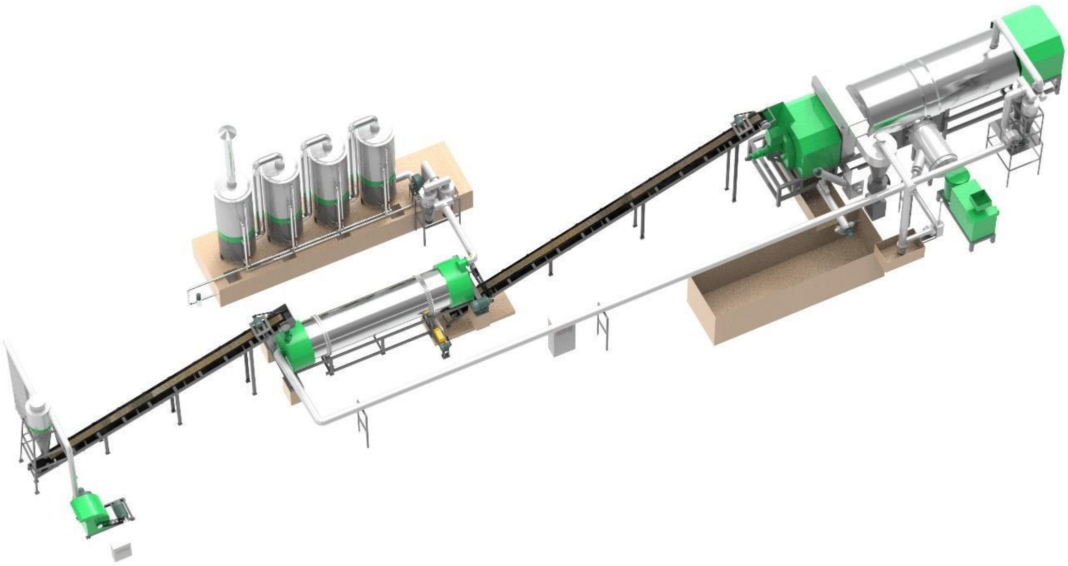

Figure 4: Biochar Reactor and Rotary Dryer Layout

Emissions monitoring

During production, emissions monitoring will be conducted to ensure the project meets expected waste emissions targets as well as complies with the standards set by the Tanzanian Environmental standards and upheld by NEMC (National Environmental Management Council). This will be done with in situ emissions monitoring equipment with the sensors placed next to the flue stack of the reactor.

Post Production and Application

Please note that all CO_2 calculations are initial calculations and though they are in the correct order of magnitude, they have been updated with final calculations defined in the PDD.

DEC commits that no biochar produced from the Sifuri Halisi Project will be sold or used for combustion and this is a condition of supply of biochar to any end user. It is anticipated that the entire production from this facility will be consumed or applied by the end user within 150km of the Sifuri Halisi Project site. In addition, DEC's traceability system will extend to end user ownership. This data can then be used to calculate the total distance from the project site that DEC's biochar has travelled.

Disaggregation strategy

DEC has engaged several disaggregation partners to put the resultant biochar to range of productive uses. As the Sifuri Halisi Project will be the first commercial scale biochar reactor in Tanzania, one of DEC's goals is to develop the value propositions for biochar through East Africa. Significant revenues are not forecast from this side of the business for the first 24 months of operation. Instead, DEC seeks to develop and promote several applications which can then be valorised by additional production units and private sector partners.

It is anticipated that the majority of the biochar will be put to agricultural uses, mainly as a soil amendment. The biochar will be mixed on site with commercially purchased compost or other soil boosting additives to begin activation prior to application to soil. This biochar will be given to partners in the neighbouring area for use in smallholder farming. Initially we have partnerships with:

- The One Acre Fund, a multinational NGO,
- Rehoboth Equatorial Agtech Partners, a commercial farming company.

DEC will run experiments regarding application rates and soil types. We seek to create a sharable knowledge base which will assist in the urgent task of repairing depleted soils, adapting to a change climate, and helping farmers move out of subsistence.

DEC will run similar experiments with partners in the livestock sector using the biochar as animal feed, aquaculture sector for both feed and water filtration and purification purposes and finally in the construction industry. As sub-Saharan Africa urbanises over the coming decades, the ability to cost effectively decarbonise the construction industry will be another component of a net zero world.

Biochar mixing and activation

Whilst the final composition of any biochar based Soil Builder product is not yet known, DEC expects to use some mechanical mixing process. The additives may be a mix of compost or other organic substrates and will be mixed mechanically prior to dispatch in an on-site rotary mixer. DEC will run an extensive R&D process during the first 12-24 months of company operation to determine a Soil Builder with product market fit. However for simplicity of calculation of emissions, DEC is forecasting to mix the entire site biochar production with compost whereas in reality some biochar will not be processed further. Hours of operation of the rotary mixer will be recorded as part of routine plant operation. These records will be used to calculate actual emissions due to post production in due course.

Annual through-put of mechanical rotary mixer will be 3,035T (2,759T of raw biochar, 276T of compost). Emissions from the process are calculated using the following formula:

$$E_{p,y} = SUMi(Q_{i,y,energy} * COEF_{i,y})$$

Where:

$E_{p,y}$	Emissions due to biochar bulk mixing with compost (tCO_2e)
$Q_{i,y,energy}$	Amount of energy used
$COEF_{i,y}$	CO_2 emissions coefficient of type of energy used

To mix the annual production of the Sifuri Halisi Project site will generate 18 tCO2e[13] per year. These represent the total annual emissions due to post production and application. For transportation emissions see Leakage section below.

[13] From tab Ep y (eq14) in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx"

Figure 5: Rotary mixer to be used for biochar activation

Other energy consumption

The Sifuri Halisi Project site will consume other small amounts of energy than just those listed above. The emissions from these other sources (factory lighting, office equipment, other smaller processing machinery) need to be included in the carbon accounting as they would not have existed if the project was not operational. These emissions are estimated below but will be quantified during production and operation in a similar manner to the recording of other elements such as machine run time and factory mass balance.

$$E_{p,y} = SUMi(Q_{i,y,energy} * COEF_{i,y})$$

Where:

$E_{p,y}$	Emissions due to other energy consumption (tCO_2e)
$Q_{i,y,energy}$	Amount of energy used
$COEF_{i,y}$	CO_2 emissions coefficient of type of energy used

Leakage

DEC forecasts minimal leakage from the Sifuri Halisi Project. This is due to some factors common to many biochar projects and some factors unique to the Sifuri Halisi Project. Leakage is calculated using to following formula:

$$LE_y = LE_{bl} + LE_{as} + LE_{bd} + LE_{ts} + LE_{tap}$$

Where:

LE_y	Total leakage GHG emissions due to project activity in the year *y* (tCO_2e)
LE_{bl}	Leakage due to loss of biochar in the year *y* (tCO_2e)
LE_{as}	Leakage due to activity shift (tCO_2e)
LE_{bd}	Leakage due to biomass diversion (tCO_2e)
LE_{ts}	Leakage emissions due to transport of waste biomass feedstock (tCO_2e)
LE_{tap}	Leakage emissions from transportation of biochar from the production facility to the site of end application in the year *y* (tCO_2e)

DEC estimates all the above leakage input variables to be **zero** for the following reasons:

LE_{bl}	Leakage due to loss of biochar in the year *y* (tCO_2e)
LE_{as}	As all biomass feedstock is currently waste "activity shift" leakage is therefore zero
LE_{bd}	As all biomass feedstock would have decayed or combusted, "biomass diversion" leakage is therefore zero.
LE_{ts}	All biomass feedstock is sourced from within 200km of the Sifuri Halisi Project site and therefore leakage is considered *de minimis*. Transport records and vehicle logs will be kept as part of DEC's Quality Assurance System. These can be consulted during periodic regular audits to ensure all biomass is sourced from within 200km. For any biomass sourced from outside the 200km zone, leakage emissions will be calculated accordingly.
LE_{tap}	All biochar will be utilised/applied by the end user within 200km of the Sifuri Halisi Project site and therefore leakage is considered de minimis. Transport records and vehicle logs will be kept as part of DEC's Quality Assurance System. These can be consulted during periodic regular audits to ensure all biochar is delivered to the end

user within 200km. For any biochar that is delivered outside the 200km zone, leakage emissions will be calculated accordingly.

Therefore emission leakage from the Sifuri Halisi Project is estimated at **zero** tCO_2e per year of operation.

Net Removals

The 1T/hr reactor that DEC will install at the Sifuri Halisi Project site represents Tanzania's first high technology biochar production facility. To calculate the final greenhouse gas balance position of the project, the following calculation is used:

$$ER_y = (ER_{ps} + ER_{ss} + ER_{as}) - LE_y$$

Where:

ER_y	Final annual net emissions removal (tCO_2e)
ER_{ps}	Production stage removals
ER_{ss}	Sourcing stage emissions
ER_{as}	Application stage emissions
LE_y	Leakage emissions

Entering all the values calculated above gives a final annual net greenhouse gas removal of **5,439 tCO_2e**[14] from DEC's Sifuri Halisi Project site.

[14] From tab Ery (eq17) in "Sifuri Halisi Project Net removals calculations sheet 2022-01.xlsx"

Appendices

Sifuri Halisi Project Net removals calculations sheet.xlsx

Pyrolizer Specifications

SGS emissions test

Sifuri Halisi Project Gantt chart

List of Capex for Sifuri Halisi Project

Cash flow estimate for Sifuri Halisi Project