How to harness the potential of biomass-based solutions for carbon removal

The biochar case

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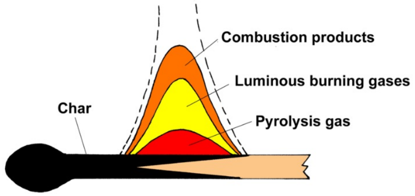
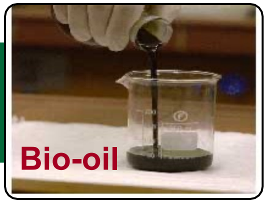
The Pyrolysis process

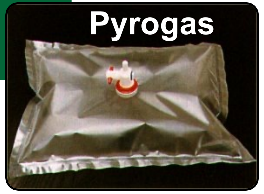
THERMOCHEMICAL DECOMPOSITION (CONVERSION) OF ORGANIC MATERIALS THROUGH HEATING IN ANAEROBIC CONDITIONS



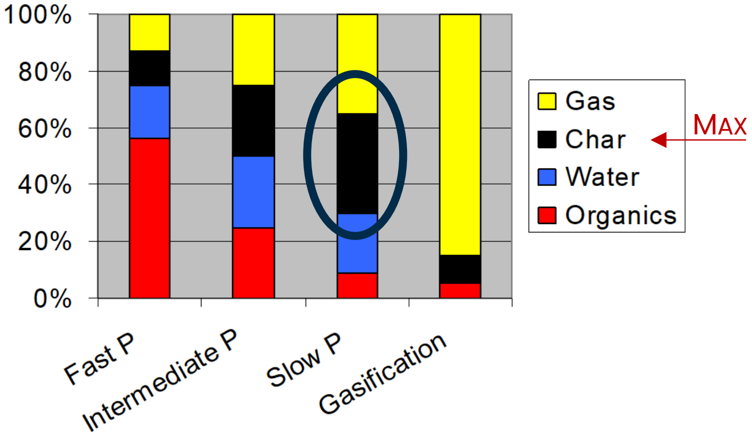
PRODUCTS OF THERMOCHEMICAL CONVERSION

- **SOLID**
- **LIQUID**
- **GAS**





- *Pyrolysis (Slow, Fast), Gasification, Hydrothermal Carbonisation*
- ***SLOW Pyrolysis**: very **robust and mature technology**. **Many reactor** types available at **any size**.*
- *A **Multi-Feedstock** technology*



SLOW PYROLYSIS

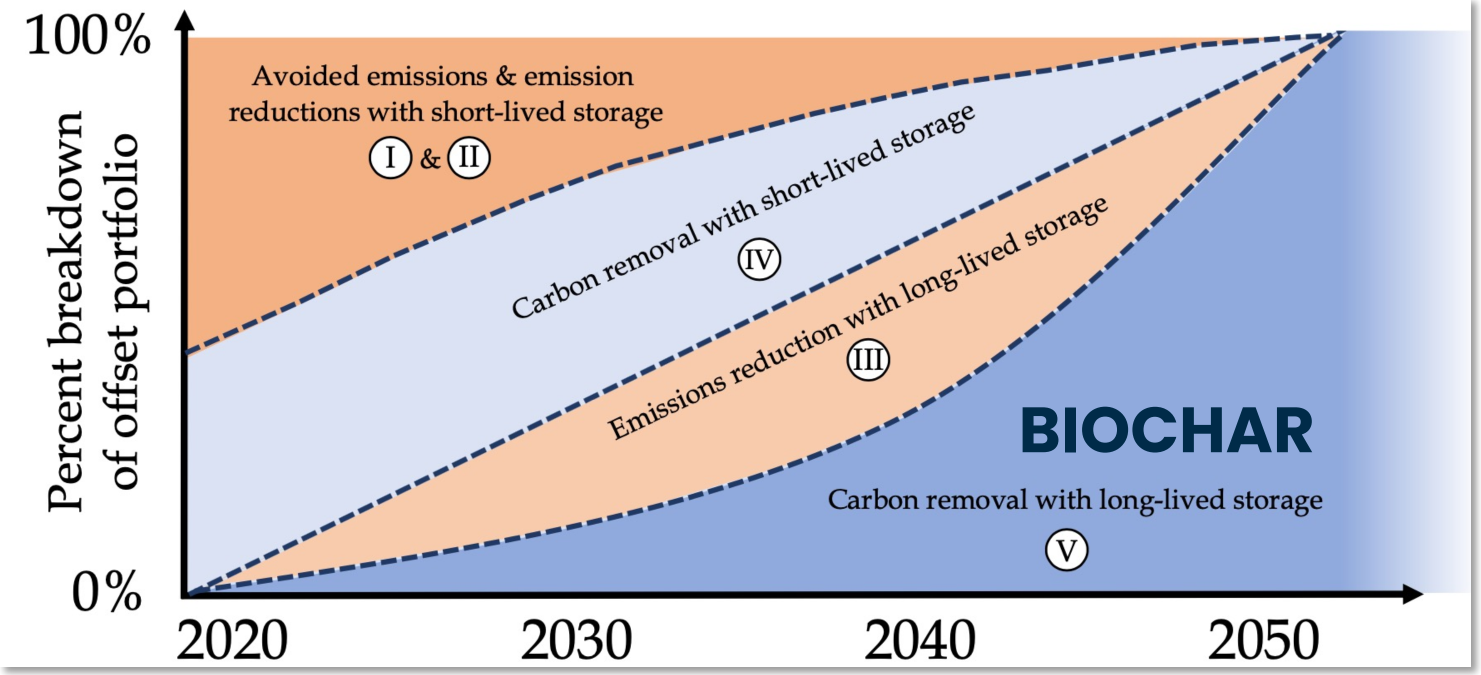
TYPICAL PROCESS TEMPERATURE: 400 ÷600 ºC

LONG RESIDENCE TIME OF SOLIDS AND VAPORS

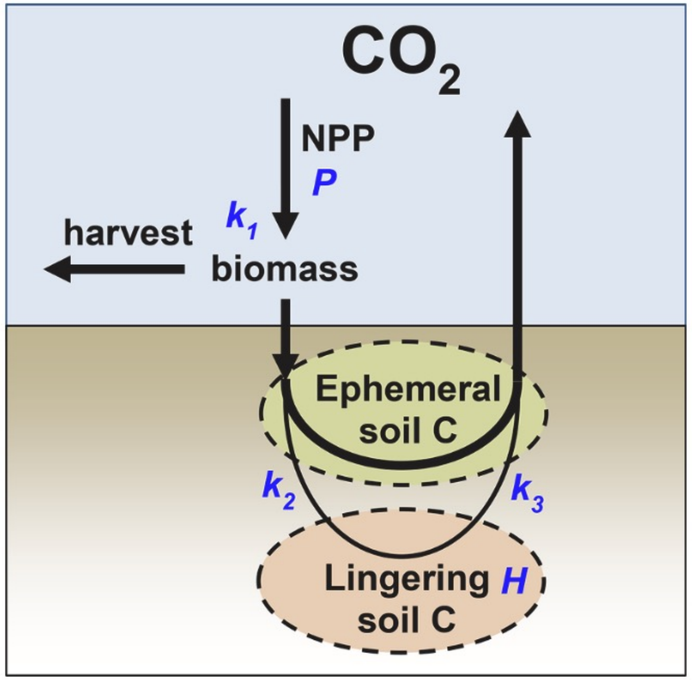
LOW HEATING RATE: 0,1 ÷2 ˚C s^{-1}

PRODUCTS → CHAR + BIO-OIL + GAS

Biochar
A long-lived storage



Adapted from: The Oxford Principles for Net Zero Aligned Carbon Offsetting, September 2020, University of Oxford



Geoderma 416 (2022) 115810

Table 2 Kinetic parameters of the double first-order exponential decay model describing biochar decomposition in soils. Values represent means ± standard errors

	Size	Decomposition rate	Mean residence time
Labile C pool	3 ± 0.6%	0.0093% day^{-1}	108 ± 196 days
Recalcitrant C pool	97 ± 0.6%	0.0018% $year^{-1}$	556 ± 483 years

GCB Bioenergy (2016) **8**, 512–523, doi: 10.1111/gcbb.12266

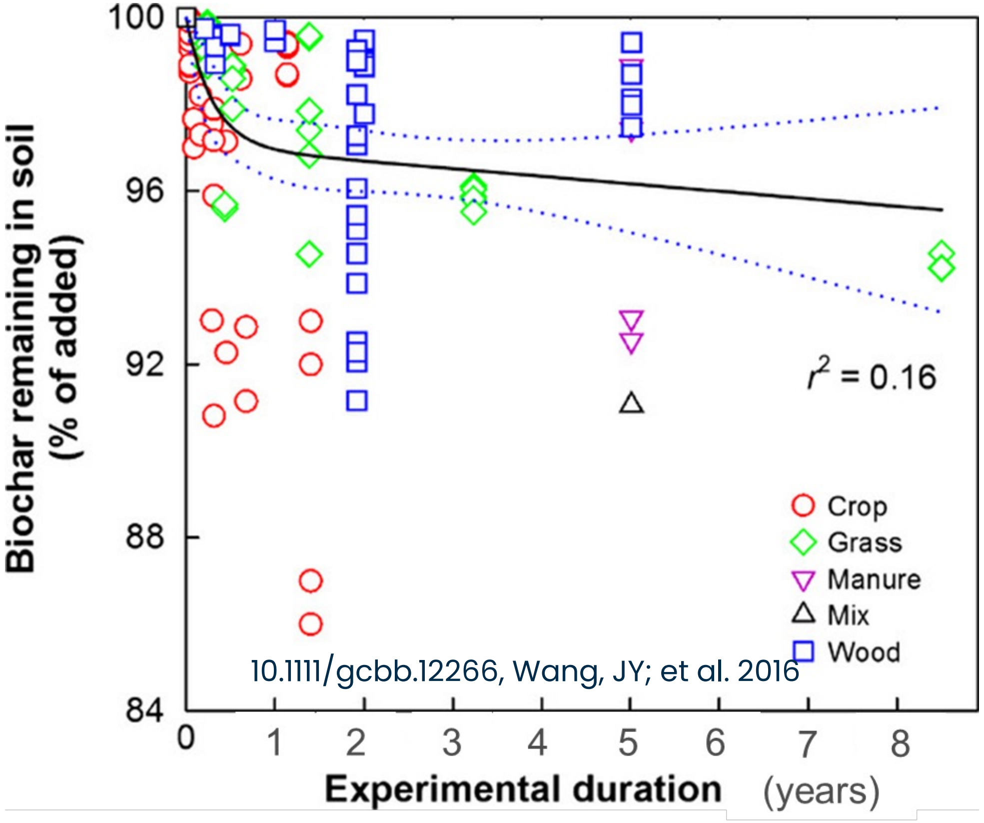
[..] We conclude that biochar can persist in soils on a <u>centennial scale</u> and that it has a positive effect on SOM dynamics and thus on C sequestration.

Biochar - Carbon decay rate

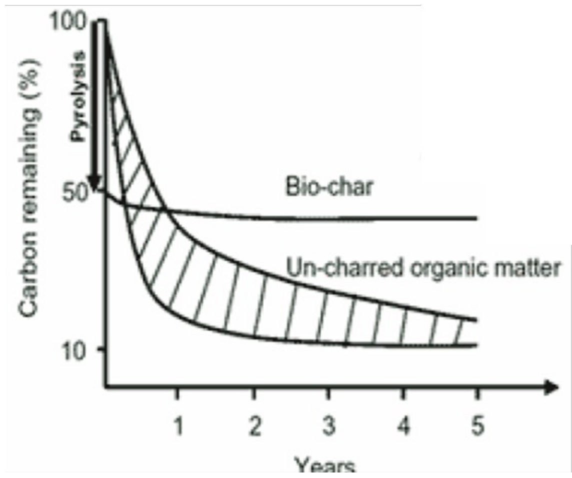
Model of decay rates:

- labile fractions (3% of biochar) = 3% /y (108 days)
- **recalcitrant fractions (97% of biochar)** = **0.0018% /y**(**556 y**)

Models based on 10 years experiments.



10.1111/gcbb.12266, Wang, JY; et al. 2016



IMAP project (Evidence Map)

- >7000 abstracts screened
- >1900 full texts screned
- Around **600** meta-analyses selected and analysed

https://wikis.ec.europa.eu/display/IMAP/Impacts+of+farming+practices+on+environment+and+climate

REDII (2018)

Implementing Regulation (2022)

Official Journal of the European Union L 328

English edition — Legislation — Volume 61 — 21 December 2018

Contents

(1) Text with EEA relevance.

EN

Acts whose titles are printed in light type are those relating to day-to-day management of agricultural matters, and are generally valid for a limited period.

The titles of all other acts are printed in bold type and preceded by an asterisk.

Official Journal of the European Union L 168

English edition — Legislation — Volume ... — 27 June ...

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II

(Non-legislative acts)

REGULATIONS

COMMISSION IMPLEMENTING REGULATION (EU) 2022/996 of 14 June 2022 on rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land- use change-risk criteria

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (1), and in particular Article 30(8) thereof,

Whereas:

(1) Directive (EU) 2018/2001 expands the role of voluntary schemes to include the certification of the compliance of biomass fuels with sustainability and greenhouse gas (GHG) emissions saving criteria and the compliance of renewable liquid and gaseous transport fuels of non-biological origin and recycled carbon fuels with the respective GHG emissions saving criteria. Furthermore, the voluntary schemes can be used to certify biofuels, bioliquids and biomass fuels with low indirect land-use change-risk.

(2) In order to establish whether biofuels, bioliquids, biomass fuels, renewable gaseous and liquid transport fuels of non-biological origin and recycled carbon fuels comply with the requirements of Directive (EU) 2018/2001, the correct and harmonised functioning of voluntary schemes is essential. Harmonised rules should therefore be established, to apply across the certification system, bringing about the necessary legal certainty on the rules applicable to economic operators and voluntary schemes.

(3) With a view to minimising the administrative burden, the implementing rules should be proportionate and limited to what is required to ensure that compliance with the sustainability and GHG emissions saving criteria and other requirements is verified in an adequate and harmonised manner that minimises the risk of fraud to the greatest extent possible. The implementing rules should therefore not be considered as a comprehensive standard but rather as minimum requirements. The voluntary schemes may accordingly complement these rules as appropriate.

(4) Economic operators may decide at any time to participate in a different voluntary scheme. However, in order to prevent an economic operator that has failed an audit under one scheme from immediately applying for certification under another scheme, all schemes receiving an application from an economic operator should require that operator to supply information about whether it failed an audit in the previous 5 years. This should also apply to situations where the economic operator has a new legal personality but remains the same in substance, so that minor or purely formal changes, for instance, in the governance structure or the scope of activities, do not exempt the new economic operator from such a rule.

(1) OJ L 328, 21.12.2018, p. 82.

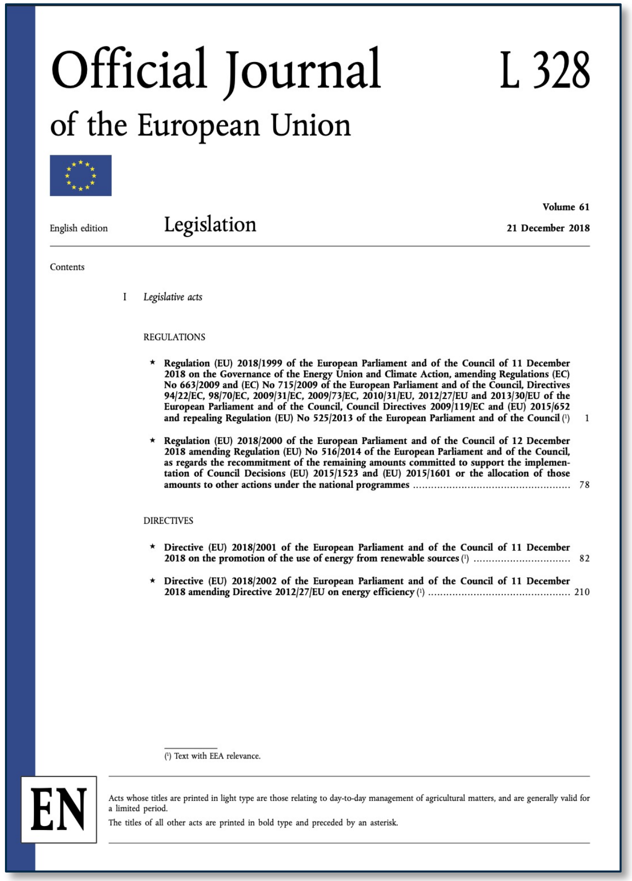
Carbon and Sust.Fuels: REDII

(a) greenhouse gas emissions from the production and use of biofuels shall be calculated as:

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr},$$

where

E	=	total emissions from the use of the fuel;
e_{ec}	=	emissions from the extraction or cultivation of raw materials;
e_l	=	annualised emissions from carbon stock changes caused by land-use change;
e_p	=	emissions from processing;
e_{td}	=	emissions from transport and distribution;
e_u	=	emissions from the fuel in use;
e_{sca}	=	emission savings from soil carbon accumulation via improved agricultural management;
e_{ccs}	=	emission savings from CO_2 capture and geological storage; and
e_{ccr}	=	emission savings from CO_2 capture and replacement.



Official Journal of the European Union

L 328

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I *Legislative acts*

REGULATIONS

DIRECTIVES

([1]) Text with EEA relevance.

EN

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6. For the purposes of the calculation referred to in point 1(a), greenhouse gas emissions savings from improved agriculture management, e_{sca}, such as shifting to reduced or zero-tillage, improved crop/rotation, the use of cover crops, including crop residue management, and the use of organic soil improver (e.g. compost, manure fermentation digestate), shall be taken into account only if solid and verifiable evidence is provided that the soil carbon has increased or that it is reasonable to expect to have increased over the period in which the raw materials concerned were cultivated while taking into account the emissions where such practices lead to increased fertiliser and herbicide use ([1]).

Solid evidence C increase to be provided

Carbon and Sust.Fuels: REDII–Implementing Regulation

(a) greenhouse gas emissions from the production and use of biofuels shall be calculated as:

$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr},$$

where

$$e_{sca} = (CS_A - CS_R) \times 3{,}664 \times 10^6 \times \frac{1}{n} \times \frac{1}{P} - e_f$$

Where:

CS_R	is the mass of soil carbon stock per unit area associated with the reference crop management practice in Mg of C per ha.
CS_A	is the mass of soil estimated carbon stock per unit area associated with the actual crop management practices after at least 10 years of application in Mg of C per ha.
3,664	is the quotient obtained by dividing the molecular weight of CO_2 (44,010 g/mol) by the molecular weight of carbon (12,011 g/mol) in g CO_{2eq}/g C.
n	is the period (in years) of the cultivation of the crop considered.
P	is the productivity of the crop (measured as MJ biofuel or bioliquid energy per ha per year).
ef	emissions from the increased fertilisers or herbicide use

Improved agriculture management practices, accepted for the purpose of achieving emission savings from soil carbon accumulation, include shifting to reduced or zero-tillage, improved crop/rotation, the use of cover crops, including crop residue management, and the use of organic soil improver (e.g. compost, manure fermentation, digestate, biochar, etc.).

The calculation of the actual values of CS_R and CS_A shall be based on measurements of soil carbon stocks. The measurement of CS_R shall be carried out at farm level before the management practice changes in order to establish a baseline, and then the CS_A shall be measured at regular intervals no later than 5 years apart.

ANNEX V

METHODOLOGY FOR DETERMINING THE EMISSION SAVINGS FROM SOIL CARBON ACCUMULATION VIA IMPROVED AGRICULTURAL MANAGEMENT

II

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Carbon and Sust.Fuels: REDII–Implementing Regulation

ANNEX VI

NON-EXAUSTIVE LISTS OF EXAMPLES OF ESSENTIAL MANAGEMENT AND MONITORING PRACTICES TO PROMOTE AND MONITOR SOIL CARBON SEQUESTRATION AND SOIL QUALITY

Examples of essential soil management practices to promote soil carbon sequestration (given the absence of residues) and promote soil quality

Requirement	Soil quality parameter
At least a 3-crop rotation, including legumes or green manure in the cropping system, taking into account the agronomic crop succession requirements specific to each crops grown and climatic conditions. A multi-species cover crop between cash crops counts as one.	Promoting soil fertility, soil carbon, limiting soil erosion, soil biodiversity and promoting pathogen control
Sowing of cover/catch/intermediary crops using a locally appropriate species mixture with at least one legume. Crop management practices should ensure minimum soil cover to avoid bare soil in periods that are most sensitive.	Promoting soil fertility, soil carbon retention, avoiding soil erosion, soil biodiversity
Prevent soil compaction (frequency and timing of field operations should be planned to avoid traffic on wet soil; tillage operation should be avoided or greatly reduced on wet soils; controlled traffic planning can be used).	Retention of soil structure, avoiding soil erosion, retaining soil biodiversity
No burning of arable stubble except where the authority has granted an exemption for plant health reasons.	Soil carbon retention, resource efficiency
On acidic soils where liming is applied, where soils are degraded and where acidification impacts crop productivity.	Improved soil structure, soil biodiversity, soil carbon
Reduce tillage/no tillage – Erosion control – addition of organic amendments (biochar, compost, manure, crop residues) – use of cover crops, rewetting Revegetation: planting (species change, protection with straw mulch) – landscape features – agroforestry	Increase soil organic carbon

27.6.2022 EN Official Journal of the European Union L 168/1

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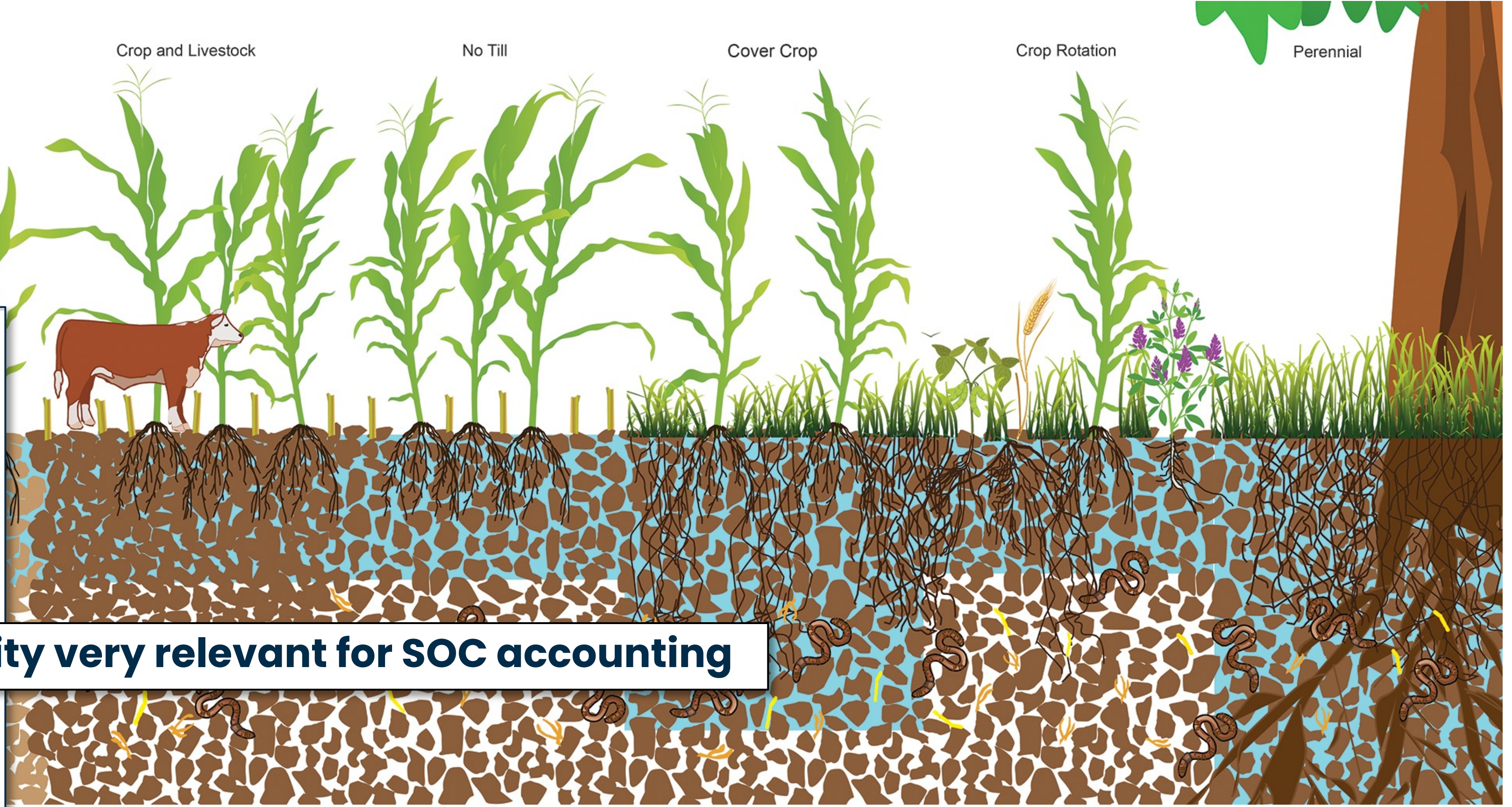
Biochar and C-farming under REDII-IR

- ✓ **Quantification, Permanence and Additionality for Biochar**
  - **verifiable and measurable, accuracy ensured (evidence of product characteristics and incorporation in soil)**
  - **long-lived C removal and use (CCU)**
  - **amounts of C sequestered is related to the energy yield per ha**
  - **the highest C-removal threshold in REDII-IR (45 gCO_2/MJ)**
- ✓ **Methodology to implement REDII-IR: under development**
  - **Soil sampling and C accounting: assessment of C-removal should be different for biochar and other Carbon-farming methods**
- ✓ **Low ILUC feedstock, severely degraded land (REDII-DA).**
  - **C farming and agriculture: win-win approach. Clear co-benefits: enabler of more sustainable agriculture.**
  - **SOC threshold: to be defined**

BIKE



Bringing organic C back to soil, and promoting **soil health** and **fertility** , are key elements for Sus
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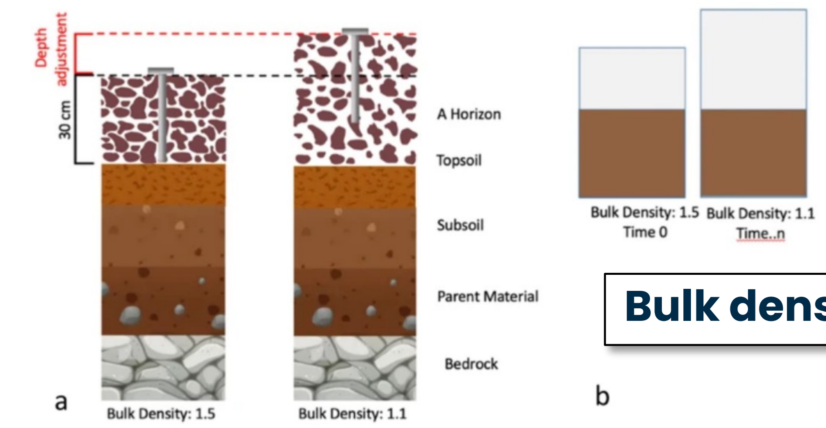
Figure 1



(**a**) Example of pedon alteration due to changes in bulk density over time showing the position of the soil sampling device from the soil surface to the same fixed depth. (**b**) Example of pedon after the correction showing the difference in air space, while the soil mass remains constant.

Bulk density very relevant for SOC accounting

Comparing infiltration rates in soils managed with conventional and alternative farming methods: A meta-analysis
Andrea D. BascheMarcia S. DeLonge

FOOD, FEED AND ENERGY (FUELS)

Reverse ILUC approach:
Barley & Camelina in recovered soil in Spain.

Food/feed otherwise not produced.

No fertilization | **Mineral fertilization** | **100% Compost** | **100% Biochar** | **Biochar+ Compost 10%**

Bio4A

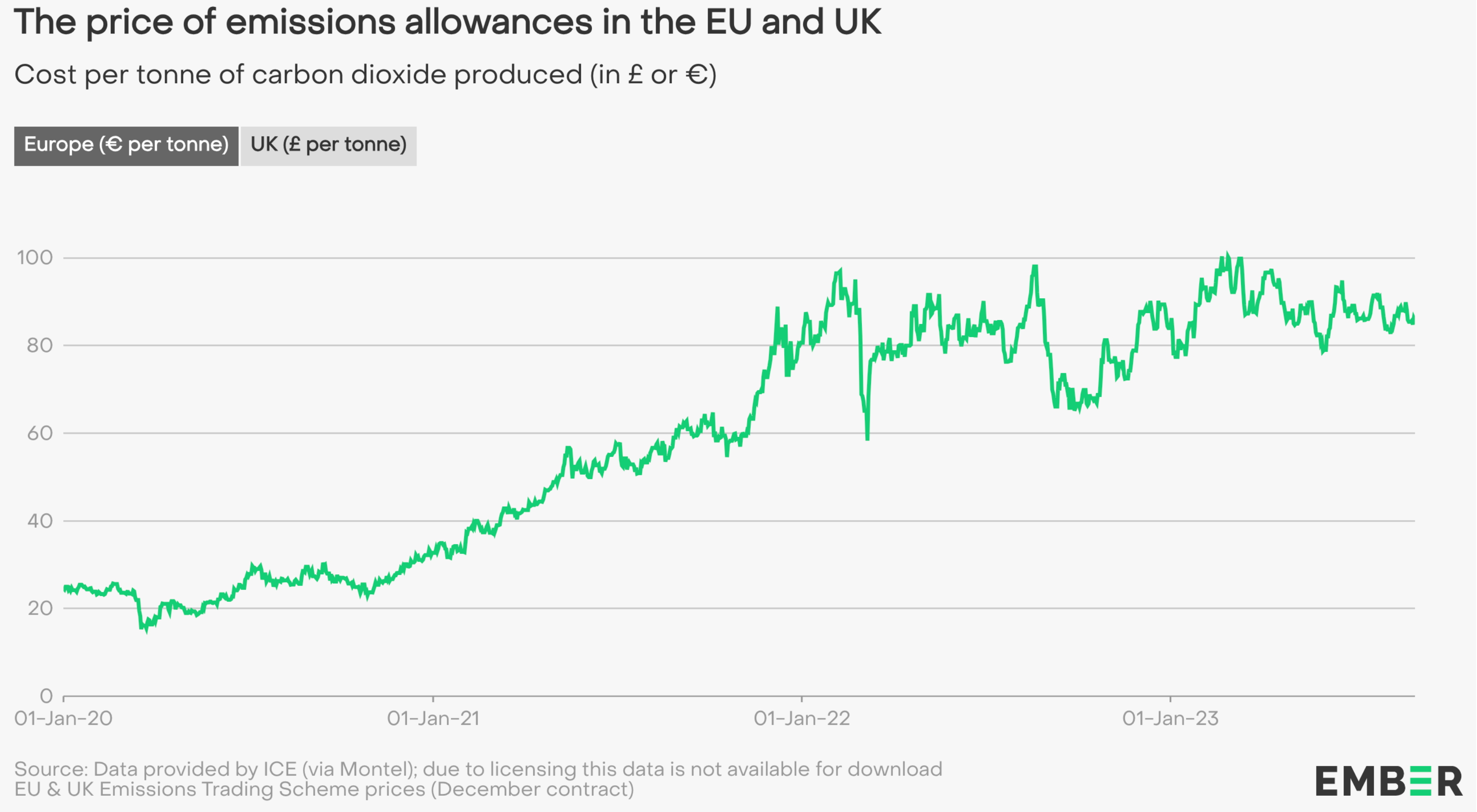
Politecnico di Torino
RE-CORD

Offsetting - Compensating

- ✓ **Low-ILUC** : Camelina&Barley in recovered land under marginalization (**BIO4A, BIKE**)
- ✓ **Offsetting CO2** at EU airport land, landside and/or airside + Circular Airports (**TULIPS**)
- ✓ **Nature-based offsetting** next to **SAF** production, or in combination with it (**BIO4A, BIKE**)

→ **Energy** can **support more sustainable agriculture** through **Biofuels Done Right models**

Biochar (as NET) and Carbon Market



Source: https://ember-climate.org/data/data-tools/carbon-price-viewer/

Thanks for your attention
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