Biochar & Energy from used substrates

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Content

Why Biochar plus bio-energy and why large scale

TNO innovation for life

Why Co-production of biochar and bio-energy?

You can make biochar by pyrolysis (only heating of the feedstock) and by gasification, i.e. using air /steam or CO_2 with too little oxygen to burn everything.
At the elevated temperature, the biomass feedstock degasses and this gas is a burnable gas.

From an environmental point of view it would be stupid not to use this as an energy source.
It can replace fossil fuel and it prevents environmentally unfriendly gasses to go to the atmosphere (gasses much worse than CO_2).

From an economic point of view, it would be stupid not to use this gas as an energy source.
It adds to your revenues, you simply have two products that both have a positive value.

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Why Biochar plus bio-energy and why large scale

TNO innovation for life

Why larger scale and what would be the right scale?

The production of biochar at the moment is too expensive for nearly all its market applications, including the bulk replacement of peat in Horticulture.

One way to reduce the price is by economy-of scale.
A good scalable technology is when twice the size does NOT cost twice the price, but less.
So scalability has been important in the technology choice.
Larger scale also means less heat losses and more energy to sell, economically AND environmentally profitable.

The right size also depends on the bio-energy, usually heat, that you want to be used.
How many hours in a year can be used and how many MWh can be used at the location?

For a greenhouse location we aim at 15 MWth input (20.000 ton) and 4500 h of heat requirement.
For an industrial location, 25 MWth and 8000 h could still be realized with local sources of bio-residues.

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1 Biochar production technologies

There is a wide variety on pyrolysis and gasification technologies available. During gasification some oxygen containing medium is used.

In the project we used:
- Auger screw reactor
- Moving bed Gasifier
- Bubbling Fluidised bed
- Gasification on a Grate

Three different sizes:
- 3 kg/h input
- 10 kg/h input
- 30 kg/h input

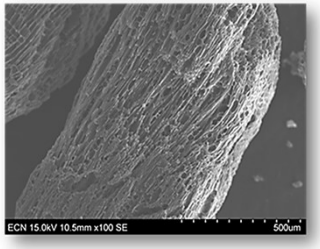
And different yields:
5% (FB) to 35% (screw)

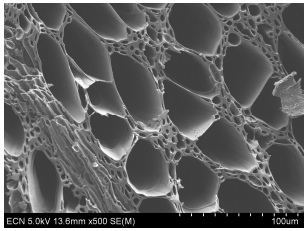
At different temperatures
400-700 C

Bottom line after 10 years of experience: You can get a good biochar out of all these technologies, using gasification and operating with attention to feedstock and Biochar quality.
However, not every technology is suitable for the used substrate (plant roots and fine soil structure), the screw reactor and grate reactor are suitable for the used substrate.

2 Quality of Biochar: used substrate

2.1 Important structural characteristics for substrates: Grain size, water holding and draining properties due to porosity





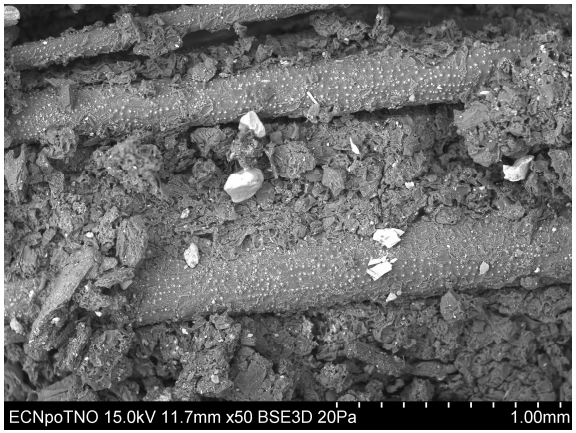
Biochar made from wood (left)
And (right) from used coir substrate
and peat substrate

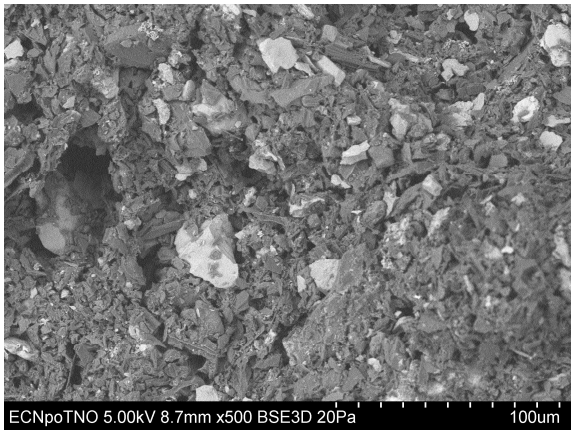
Quality passport:

Grain size should fit the mixture properties, make input material at the desired size

Light weight: 100-140 kg/m3, when low in ash

Holds roughly 4 times its own weight in water





For the used substrate, the particle size to enter the biochar making is not a choice
It is finer at the start and a lot of dust is produced.

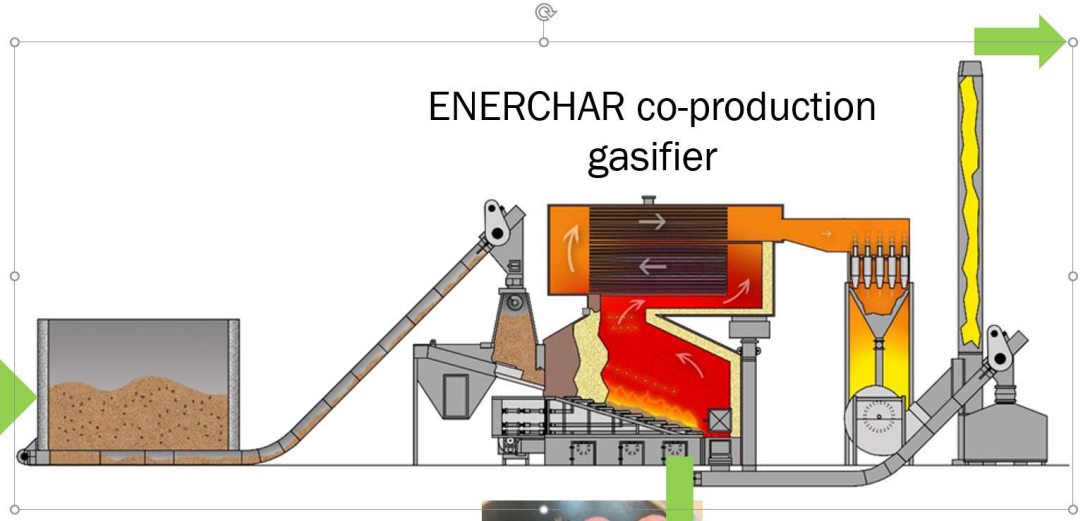
The material is still full of nutrients and therefore has a higher ash

Surface are is lower
Quality analyses on PAH and heavy metlas was fine

3. Total concept

Bio-residues

(Incl used substrates)



CO2 use in the greenhouse

Heat

Electricity

High quality biochar
No tars & very stable carbon

Or lower quality biochar
From used substrates

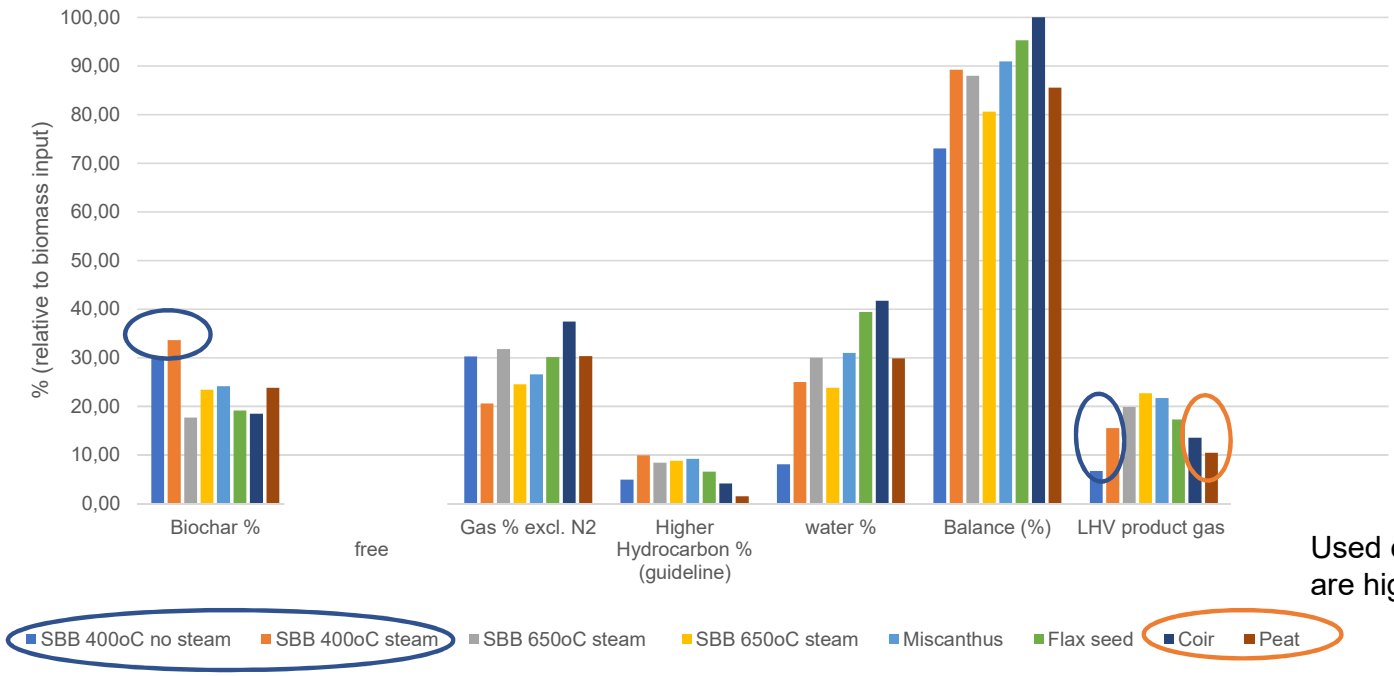
Peat replacement
In potting soil

Or lower quality biochar
from used substrates as
Part of the fertilizer

Carbon storage in soil

Co-production of bio-energy and Biochar

Co-production of bio-energy and biochar.
High yield in biochar (lower temperatures) is less energy content in the gas and lower porosity and < 5 m2/g BET surface
High ash content, as in the used substrates, means also lower gas yield



Used coir and used peat
are high in ash and hence lower in gas production

4. Environmental issues

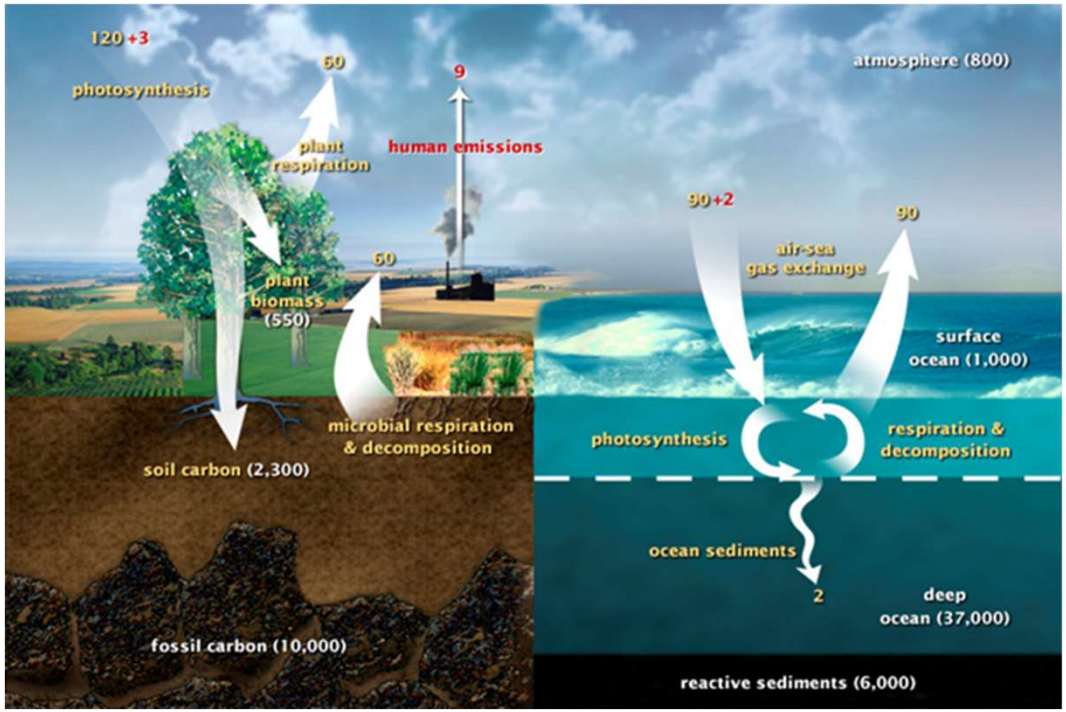
Soil carbon has a large potential as storage for C
(or CO_2 equivalents).

When the Biochar is very stable it can last for hundreds
Or maybe even thousand years (Terra Preta).

The Biochar made at higher temperatures is more stable.

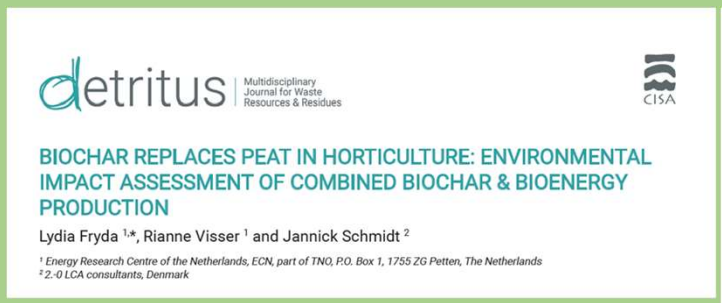
Assumed (based on literature):After 100 years, roughly 30%
is oxidized to CO_2, 70% still as carbon in soil.

Therefore, used substrates with biochar can be regarded
as carbon storage option when (mixed with compost) it is
used in the field.



Life Cycle Assesment (LCA)

LCA work in Horti-BlueC is in progress.
Previously we made an LCA based on the a functional unit for comparison being 1 MJ of Heat.
Work on used substrates still needs to be done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CISA

BIOCHAR REPLACES PEAT IN HORTICULTURE: ENVIRONMENTAL IMPACT ASSESSMENT OF COMBINED BIOCHAR & BIOENERGY PRODUCTION

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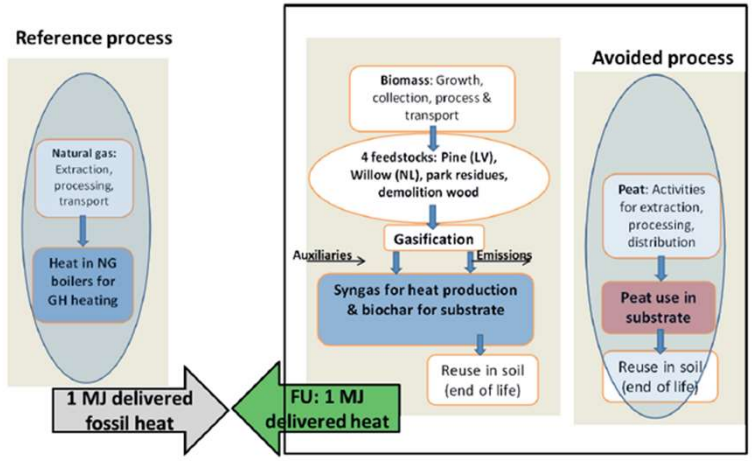
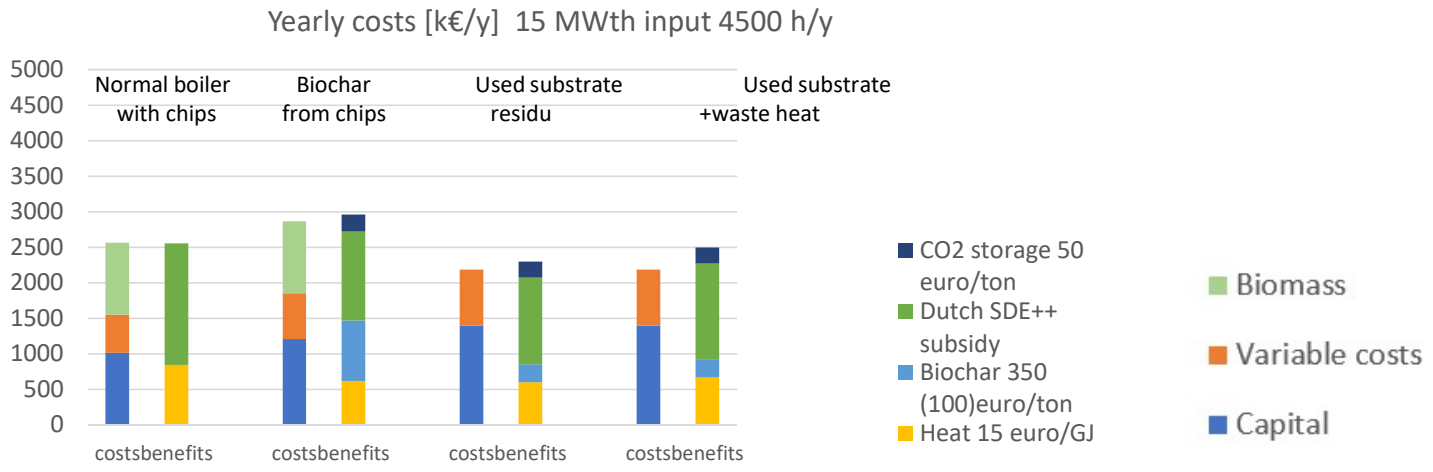


FIGURE 2: System boundaries of the syngas plus biochar system.

Cost Price of the biochar (preliminary result)



Interpretation: Case 4500 h plus subsidy, and only 15 euro/MWh (low temperature heat).
The business case for finest wood chips is only economically viable with subsidy on heat
Co-production with biochar shows similar business case, less dependent on heat, but Biomass price of 50 euro/ton (40% moisture) is too high.
Used substrate:
Input price assumed to be zero (after pretreatment), but lower biochar price (assumed at 100 euro/ton) results in similar business-case.
At 8000 h operation (industrial site) and high temperature heat price (25 euro/MWh) no subsidy is needed.

I would like to thank the EU as well as the
Province of Noord-Holland for funding.

I want to express my appreciation to the whole TNO
Team, especially Jan Hanse as the main operator, making all the biochar samples and Theo Kroon for all the instant constructions and repairs. But also Johan, Dennis and Edwin for the day- and night-shift operations.

Marco and Arnold for the on-line gas analyses, Ben for the PAH analyses and Maurice, Karine and Peter for the Prox/ult and ICP analyses, Erik Schuring for the beautiful SEM pictures Heather for LCA work, Pieter for the cost calculations and Lydia and Christiaan for contributing to the overall progress we made in the Biochar work.

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Cost Price of the biochar (preliminary)

Main assumptions for the cost calculation:

Fuel + size:
- 15 MW thermal input Enerchar installation (grate gasification), is relatively small for a commercial installation.
- 20% Biochar yield which represents 35% of the thermal input
- Without biochar production
- Fuel 1) finest wood chips (50euro/ton at 40% moisture): used (a.r.) 14,3 ton/y with biochar 20,3 ton/y. Calorif. value (LHV) 17 MJ/kg
- Fuel 2) used substrate at zero cost (-15 euro disposal is compensated by +15 euro/ton pretreatment), with biochar production 30,6 ton/y (48,5% moisture), 7,9 MJ/kg (LHV a.r.). Heat use for drying is taken into account.

- Investment (without biochar and finest wood) approx. 10 Meuro. Extra investment biochar finest wood chips 2 Meuro, Residual wood 4 Meuro.
- Depreciation: 12 years
- Interest 5%
- Annuity 11,3%
- OPEX approx. 6% of investment. Used substrate 50 keuro extra (sorting out residues of plastic).
- Revenue for heat (8000h/industry) 25 euro/GJ and (4000h/Greenhouse) 15 euro/GJ
- Biochar assumed value 350 euro/ton for wood or reed and 100 euro/ton for the biochar from used substrate (guess)

Cases:
- 4500 hours of heat delivery (Greenhouse) and with a price for the heat of 15 euro/MWh (low temperature heat)
- 8000 hours of heat delivery (industrial location or local heat network) and with a price of 25 euro/MWh (high temperature heat).

- Without Dutch SDE++ subsidy and with subsidy on heat (2022 estim as 8,5 euro/GJ)
- With CO2 credits for carbon storage in soil and CO2 credits for non-used ETS rights (no subsidy) both at 50 euro/ton CO2 eq.

Legislation on use

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Law

Fertilising products – pyrolysis and gasification materials

Have your say > Published initiatives > Fertilising products – pyrolysis and gasification materials

In preparation

Draft act

Feedback period

04 January 2021 - 15 February 2021

FEEDBACK: CLOSED

UPCOMING

Commission adoption

Planned for

First quarter 2021

About this initiative

Summary

The updated EU rules on fertilising products (Regulation 2019/1009) will apply from 16 July 2022. They lay down an exhaustive list of materials allowed in fertilising products. The initiative would extend this list by adding pyrolysis and gasification materials ('biochar').

Biochar materials are:

- rich in nutrients
- good for agriculture and the environment, and
- safe for humans, animals and plants.

This initiative therefore sets out the detailed conditions for using them in fertilising products.

Topic Single market

Type of act Delegated regulation

Expert group E01320

Quality criteria for the biochar are still being discussed

How to move forward with biochar

CONCLUSIONS AND RECOMMENDATIONS

- Produce biochar in co-production with bio-energy!
- In many aspects economy and environmental benefits go hand in hand.
- Environmentally and economically it makes sense to go for large scale (at least 15- 25 MWth input).
- Subsidy on heat is likely to be replaced in the future by CO_2 credit schemes.
  - Co-production of biochar is then the better business case.
  - Now subsidy is needed in all business cases, except 1 (residual wood Co-production incl drying by waste heat and heat delivery 8000 h (at 25 euro/MWh)).
- Cascading approach is necessary and beneficial, both from economic and environmental perspective:
  - First use in green house substrates (350 euro/ton), than carbon storage in the field (50 euro/ton CO_2 eq ?).

How to move forward with biochar

CONCLUSIONS AND RECOMMENDATIONS

- Important to make a strong case for carbon credits for biochar storage in soil after use.
- When choosing a location now: choose a location with tradable CO2 credits (natural gas)
  - Likely this location has a larger than 15 MWth installation, this makes all business cases better (economy of scale).
- A location which requires high temperature heat year-around is highly favorable.
  - Business case for 4500 h of heat delivery at a relatively low price (15 euro/MWh) only feasible for residual wood as feedstock (30 euro/ton washed and delivered at the gate) and dried with residual heat.
- Constructing an installation for co-production now, has less risks than a 100% bio-energy installation. –
  - More products means spreading the risk
  - Carbon credits seem more future proof.
  - Fall-back option still 100% bio-energy at minimal extra investment costs