Bio-Char II: Production, Characterization and Applications
Proceedings

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The role of feedstock for biochar and energy in reducing the carbon footprint of bioenergy projects — A case study in North Europe

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BIOCHAR & BIOENERGY FOR CARBON SEQUESTRATION

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INTRODUCTION

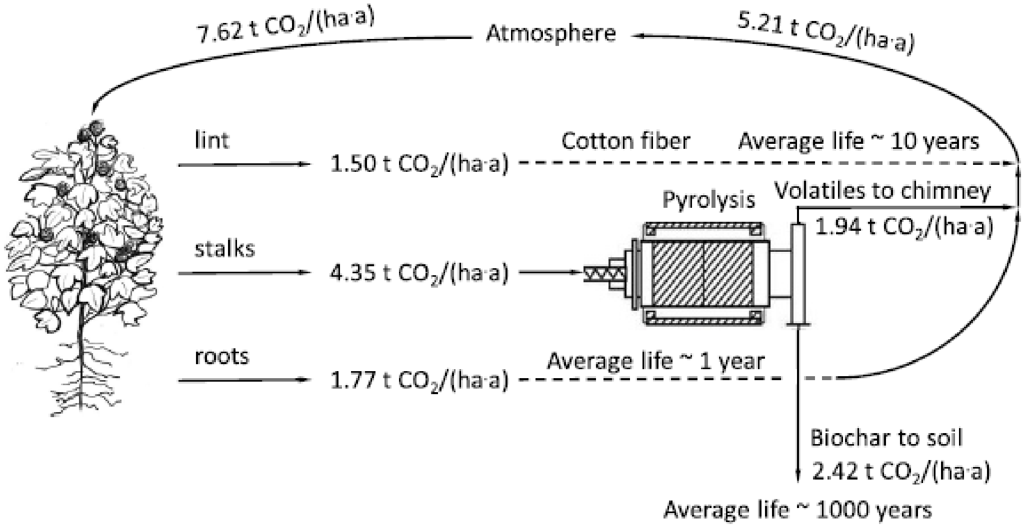
Horticulture consumes (fossil) energy: heating, CO_2, substrates (peat), fertilizer (NPK), water…

- ➢ Need to reduce fossil energy use
- ➢ Need to preserve peat bogs (reduce carbon loss)

Biochar & bioenergy as sustainable alternatives?
Which biochar?

PYROLYSIS FOR BIOCHAR PRODUCTION

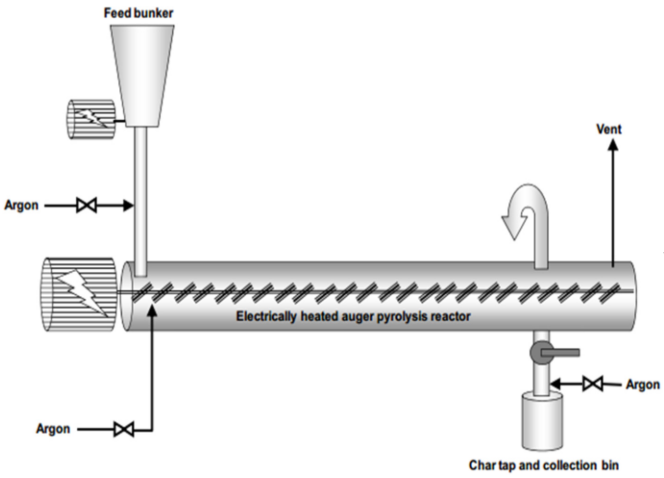
An ideal situation: high yield premium quality biochar, valorisation of co-products

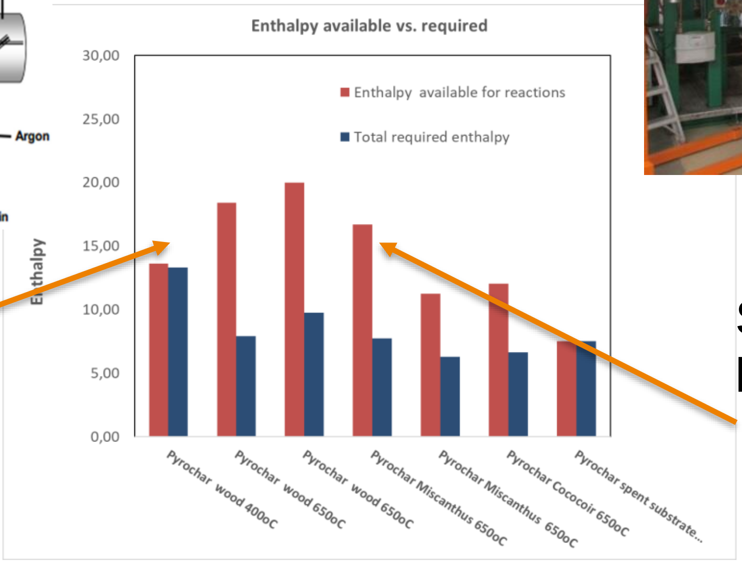


~50% yield
~25% heat surplus

Source: Schafer et al., Biomass and Bioenergy 120 (2019) 281–290

EXAMPLES & REALITY





High % @
low T

Surplus energy @
high T, low %

BIOCHAR STABILITY

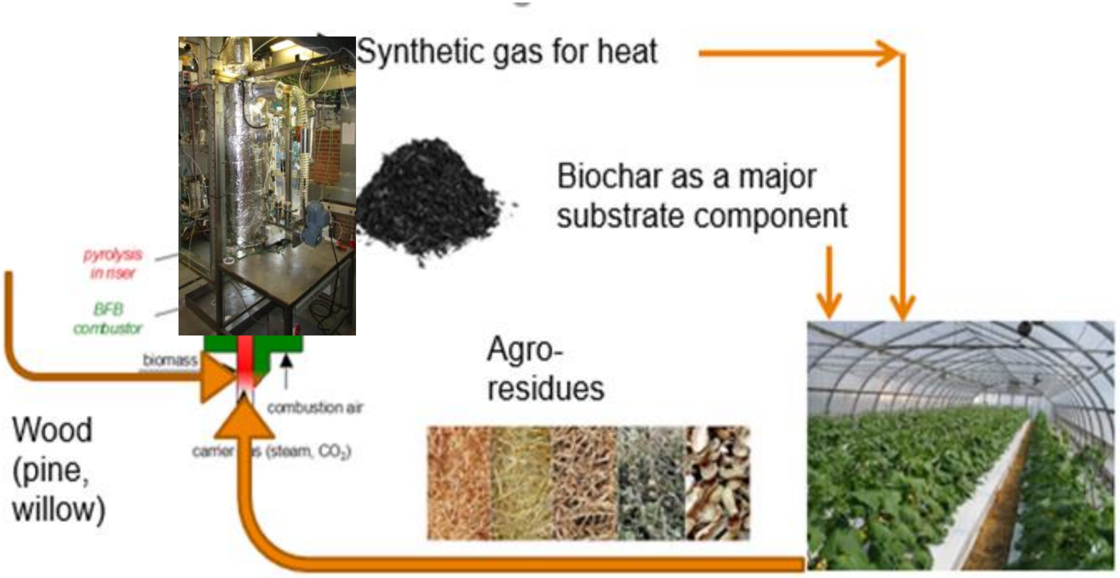
ECN › TNO innovation for life

⇒ "Edinburgh Tool" (UK Biochar Research Center): accelerated ageing method, simulates the oxidative degradation (ageing) of biochar in soil

⇒ Biochars from variable conditions have variable stability: affects CCS

Biochars & control	**% Carbon in oxidized biochar**
Wood (park residue) biochar, gasification 670ºC	90.0
Beech wood / pine wood, gasification 670ºC	97.5
Oak biochar, pyrolysis 400ºC	21.5
Oak biochar, pyrolysis 600ºC	86.1
Commercial biochar *	98.0
Pine wood biochar, gasification 670ºC	89.5
Cocoa biochar, pyrolysis at 650ºC, steam activated	98,1
Graphite *	99.0
Active Carbon 1*	99.0
Active Carbon 2*	99.0
Fresh cocoa shell	25.3

GASIFICATION FOR BIOCHAR PRODUCTION



- -High quality biochar
- -Broad range of feedstock
- **-High energy quality**

Important to co-produce Energy for the system economics

SYSTEM DESCRIPTION AND GHG STUDY

	Ener & char
Feed (kg)	3000
Total n_{eff} to energy (syngas)	0.85
Thermal output MWh	13
Biochar (m^3)	2.75
Biochar (kg)	275
CO_2 sequestration (kgCO_2 / kg char)	-2.78
Peat replacing capacity	+
Stability biochar (%)	>90
Stability peat	20%
CO_2 release peat (kgCO_2 / kg peat) (decay)	1.47

Goal of the study

- To evaluate the environmental impact of production & application of (bio)heat and biochar
- To compare with the current (reference) situation: natural gas & peat use (peat & NG substitute)

Disposal of spent substrate in soil

DATA INVENTORY & ASSUMPTIONS

- Pilot & lab scale experiments (mass and energy flows, feedstock and products composition of biochar & product gas)
- Ecoinvent database, papers, reports, literature
- Databases on emissions e.g. National inventory emissions, http://www.ipcc-nggip.iges.or.jp/EFDB/main.php
- IPCC's Global Warming Potentials (IPCC 2007).
- No distinction is made between fossil and biogenic carbon: Timing of emissions and uptake (biomass growth) is taken into account
- Use of Simapro 8.5

CO_2 BALANCE (BIOMASS, BIOCHAR, PEAT)

CO_2 balance = ***f***(growth & decay of biomass, combustion, carbon storage in biochar, decay peat & biochar) *NO Soil Organic Carbon changes assumed*

Balance over 100 year *TH* = $CO_{2,uptake/sequestration}$ - $CO_{2,\ decay}$ – $CO_{2,harvest/bioenergy}$ *

***Harvest = immediate use (combustion, release of CO_2)**

⇒CO_2 value to include in the calculation (input in the fossil CO_2 emissions table of the input file) => A “worst” case in bioenergy when carbon neutrality cannot be sure

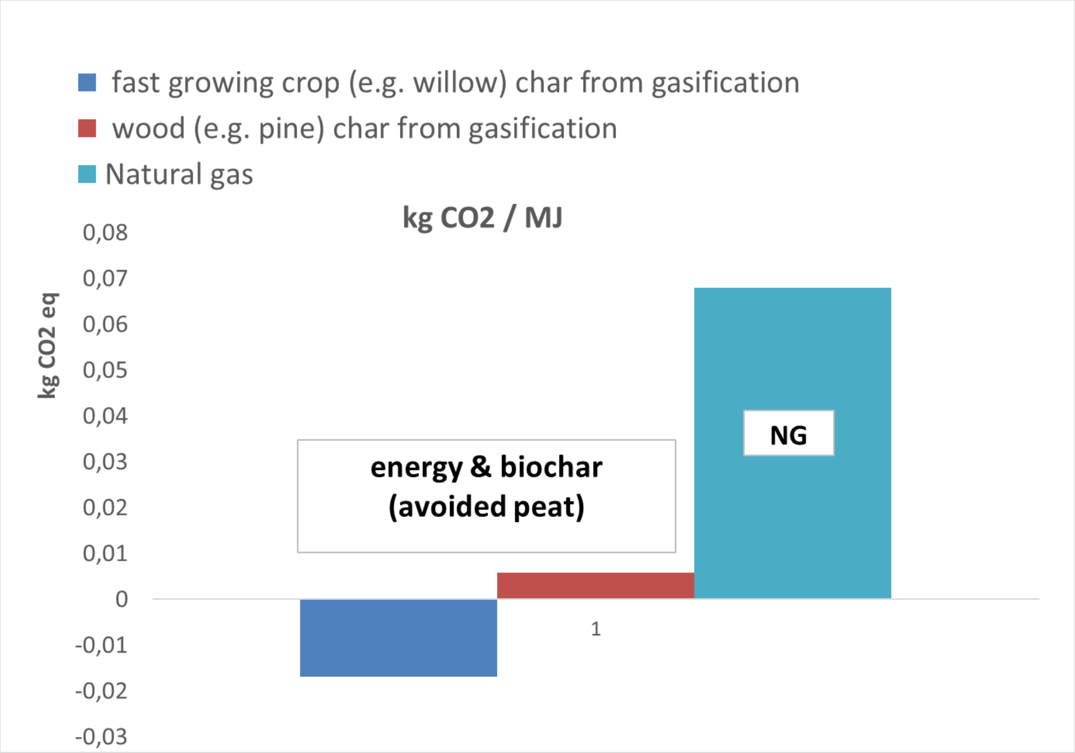
⇒ **References: *de Rosa, Schmidt etc***

ENERGY & BIOCHAR SYSTEM

<u>Ener & Char</u> :
main product =
heat delivered

biochar is
dependent

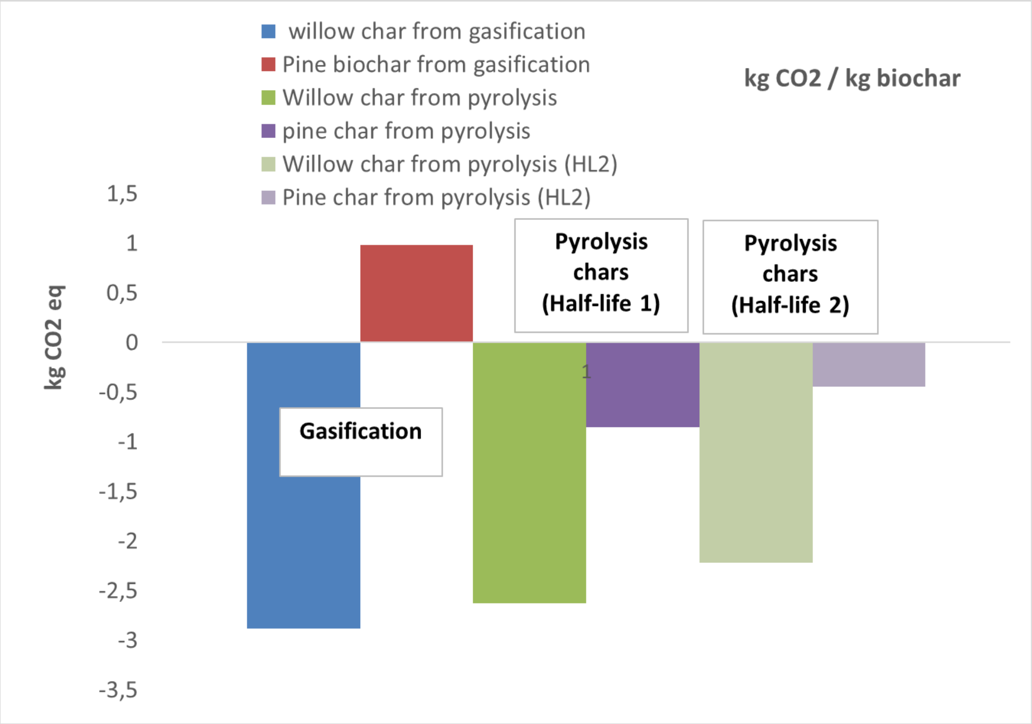
FU = 1MJ



WHAT IF WE PRODUCE MAINLY BIOCHAR

	Enerchar	PyroChar
Feed (kg)	3000	3000
Total n_{eff} to energy (syngas)	0.85	0.35
Thermal output MWh	13	4
Biochar (m^3)	2.75	6
Biochar (kg)	275	600
CO_2 sequestration (kgCO_2 / kg char)	-2.78	-1.38
Peat replacing capacity	+	?
Stability biochar (%)	>90	<40
Stability peat	20%	
CO_2 release peat (kgCO_2 / kg peat) (decay)	1.47	

CO2 EMISSIONS ENER&CHAR VS PYRO-CHAR



Ener&Char: although biochar little, gets credit from heat

PyroChar: mainly biochar, little credit from heat

This graph reflects quality of biochar

KEY MESSAGES & OUTLOOK

- Stability of biochar crucial for CCS estimation:

The CCS potential of biochar is linked with its carbon recalcitrance which can vary considerably among Low T pyrolysis and high T gasification

- Energy plus biochar: fast growing biomass provides quick CO_2 return (minimizes carbon debt)

- Biochar plus energy: also forest products become relevant, C is stored in soil for very long (CCS potential)

- Case by case study necessary, parameters to consider: stability, biochar and energy yield, feedstock origin and growth cycle, reference system

- Plans to include iLUC emissions: how will the system behave

THANK YOU

- Lydia Fryda

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