Pyrolyysi ja biohiili

Mikko Ahokas

Macon Oy

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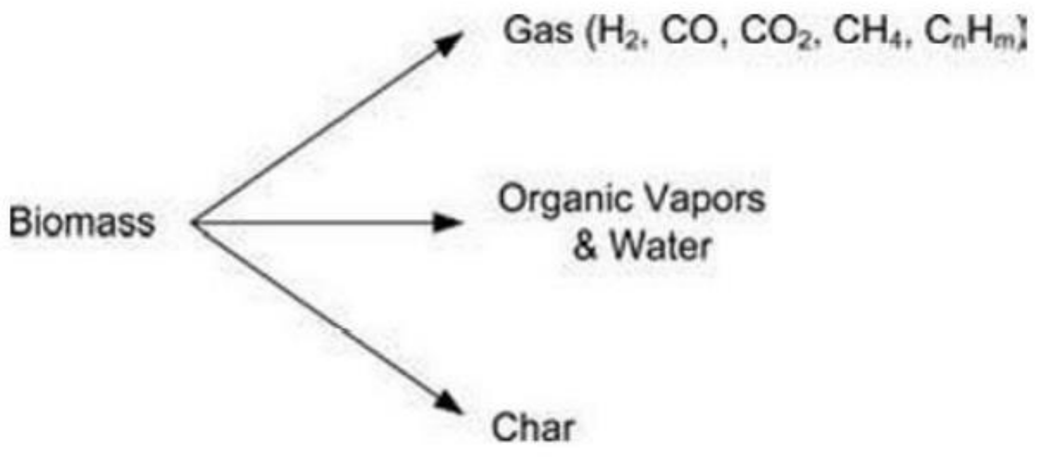
Mikä on pyrolyysi

Pyrolyysi on menetelmä jakaa aine uusiksi yhdisteiksi käyttämällä lämpöä alhaisessa happipitoisuudessa ympäristöön.

Sana pyrolyysi tulee yhdistämällä kreikan sanat tulelle ja halkeamiselle.

Pyrolyysi on lämpöprosessi, jota käytetään pääasiassa kiinteiden aineiden muuntamiseen kaasuksi, nesteeksi ja uudeksi kiinteäksi aineeksija niiden yhdistelmiä.

Polttoainelähteet voivat usein vaihdella. Tuloksena saataviin tuotteisiin vaikuttavat useat tekijät, kuten reaktioaika ,lämpötila ja reaktorityyppi (Kantarelis ym. 2012)



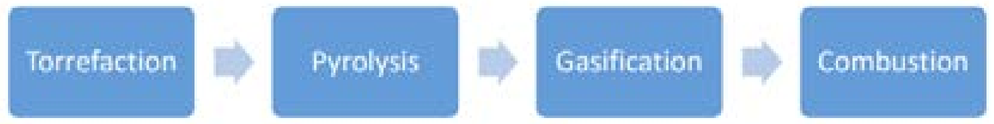


Figure 1: Thermal process depending on amount of reacting oxygen in the process

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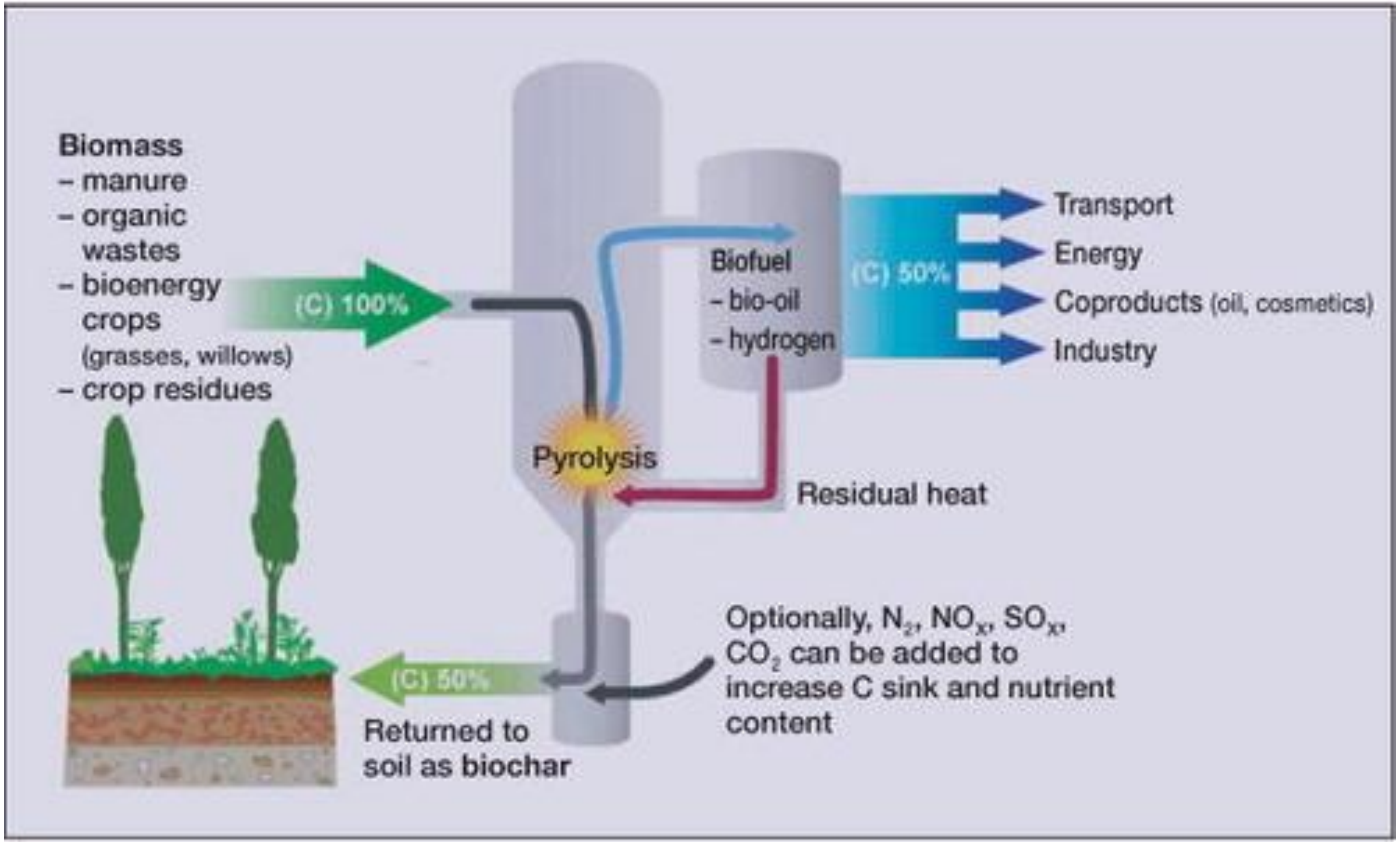
Biomass
– manure
– organic wastes
– bioenergy crops (grasses, willows)
– crop residues
(C) 100%
Pyrolysis
Biofuel
– bio-oil
– hydrogen
(C) 50%
Transport
Energy
Coproducts (oil, cosmetics)
Industry
Residual heat
Optionally, N_2, NO_x, SO_x, CO_2 can be added to increase C sink and nutrient content
(C) 50%
Returned to soil as biochar

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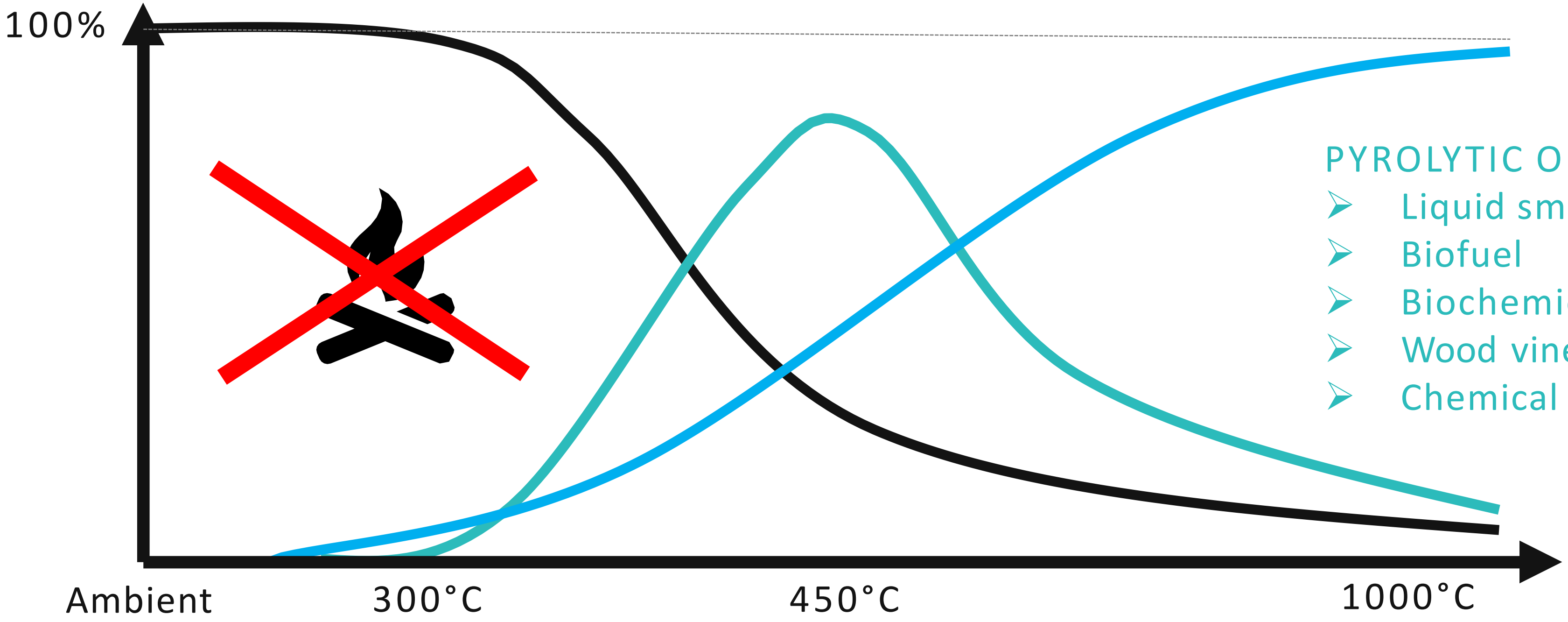
Pyrolyysin periaatteet

Pyrolyysituotteiden käyttökohteet



PYROLYTIC OIL
- Liquid smoke
- Biofuel
- Biochemicals
- Wood vinegar
- Chemical

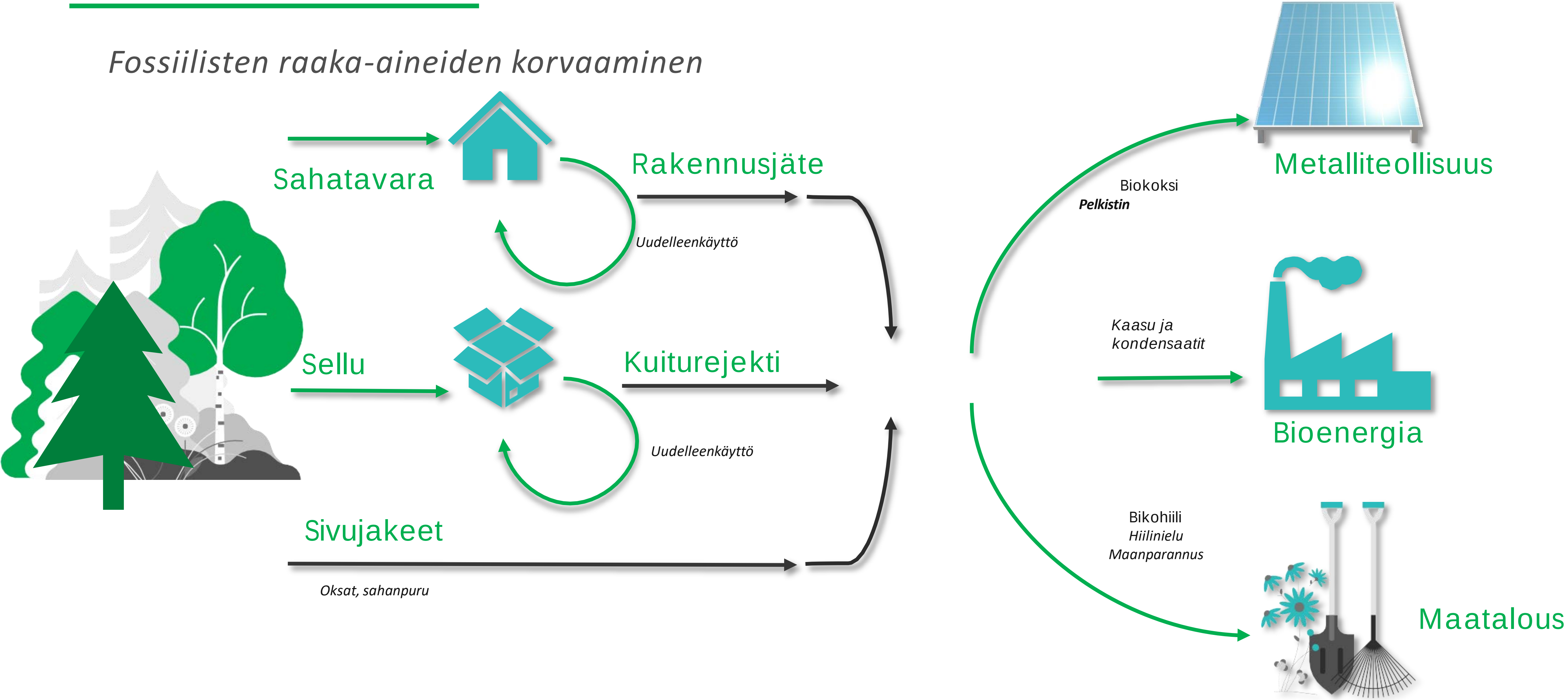
SYNGAS
- Heat
- Electricity
- CH4
- H2
- Chemicals

CHAR
- Biochar
- Biocoal
- Biocoke
- Pyrocarbon
- RcB

- Pyrolyysi on hiilipitoisten komponenttien terminen hajoaminen jossa happi ei ole läsnä

PUUN ARVOKETJU– SIVUTUOTTEIDEN HYÖDYNTÄMINEN

Fossiilisten raaka-aineiden korvaaminen



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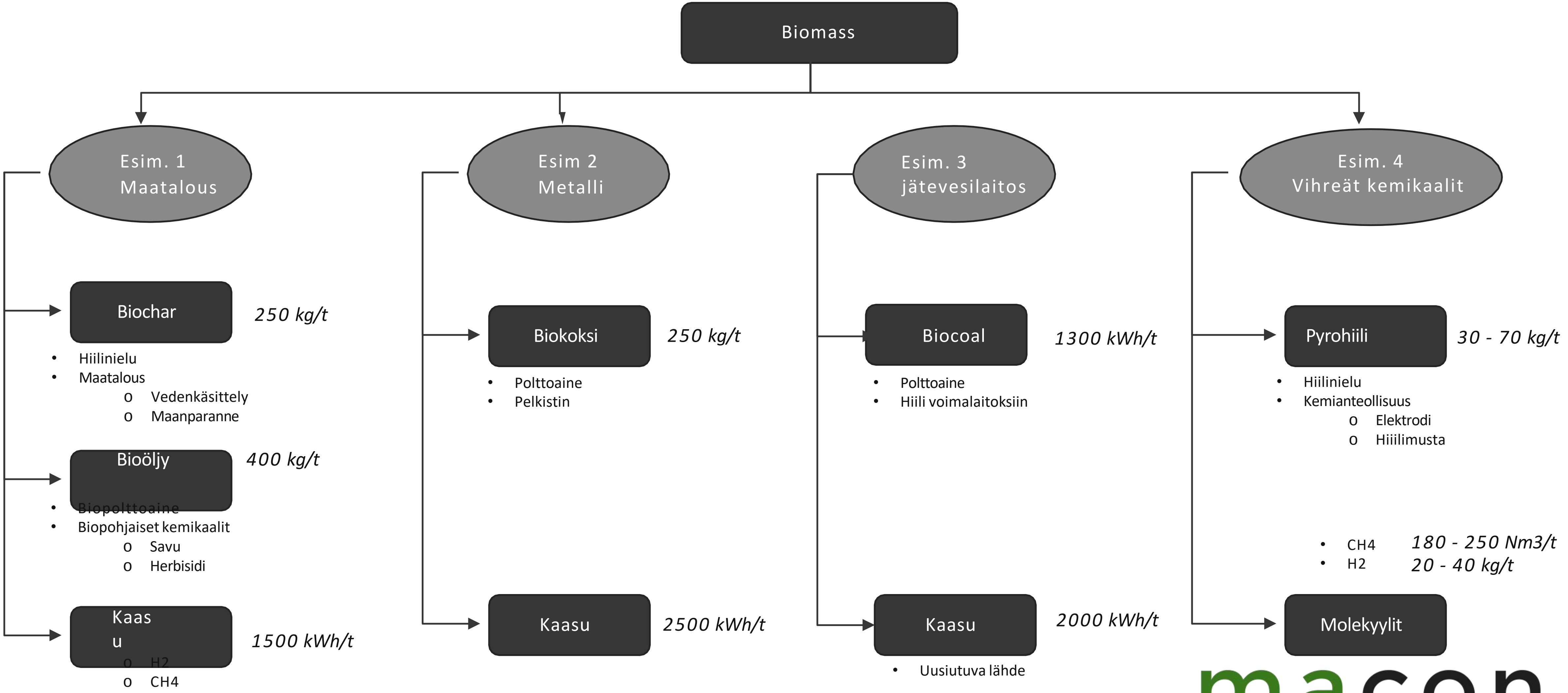
Esimerkkejä



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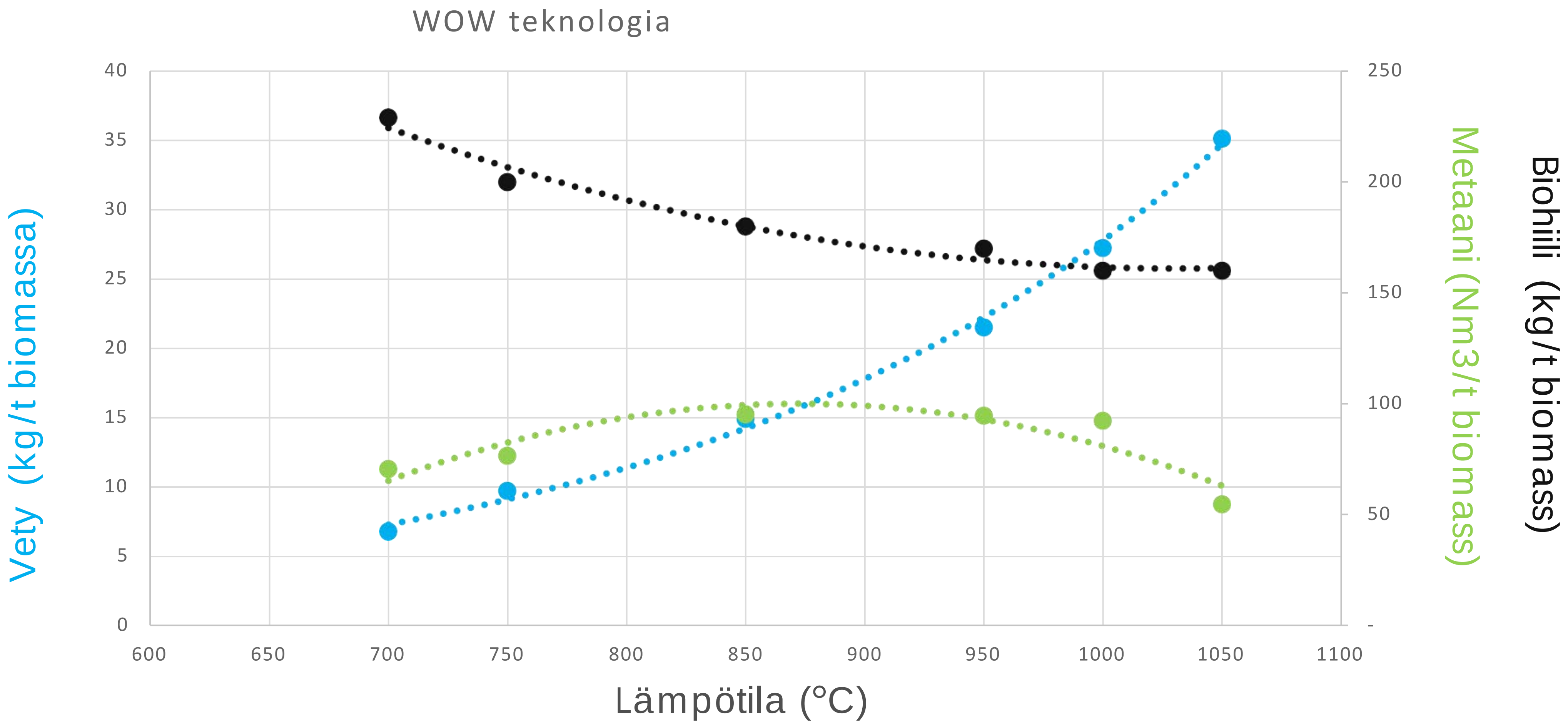
UUSIUTUVIA RAAKA-AINEITA



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TEKNOLOGIAT

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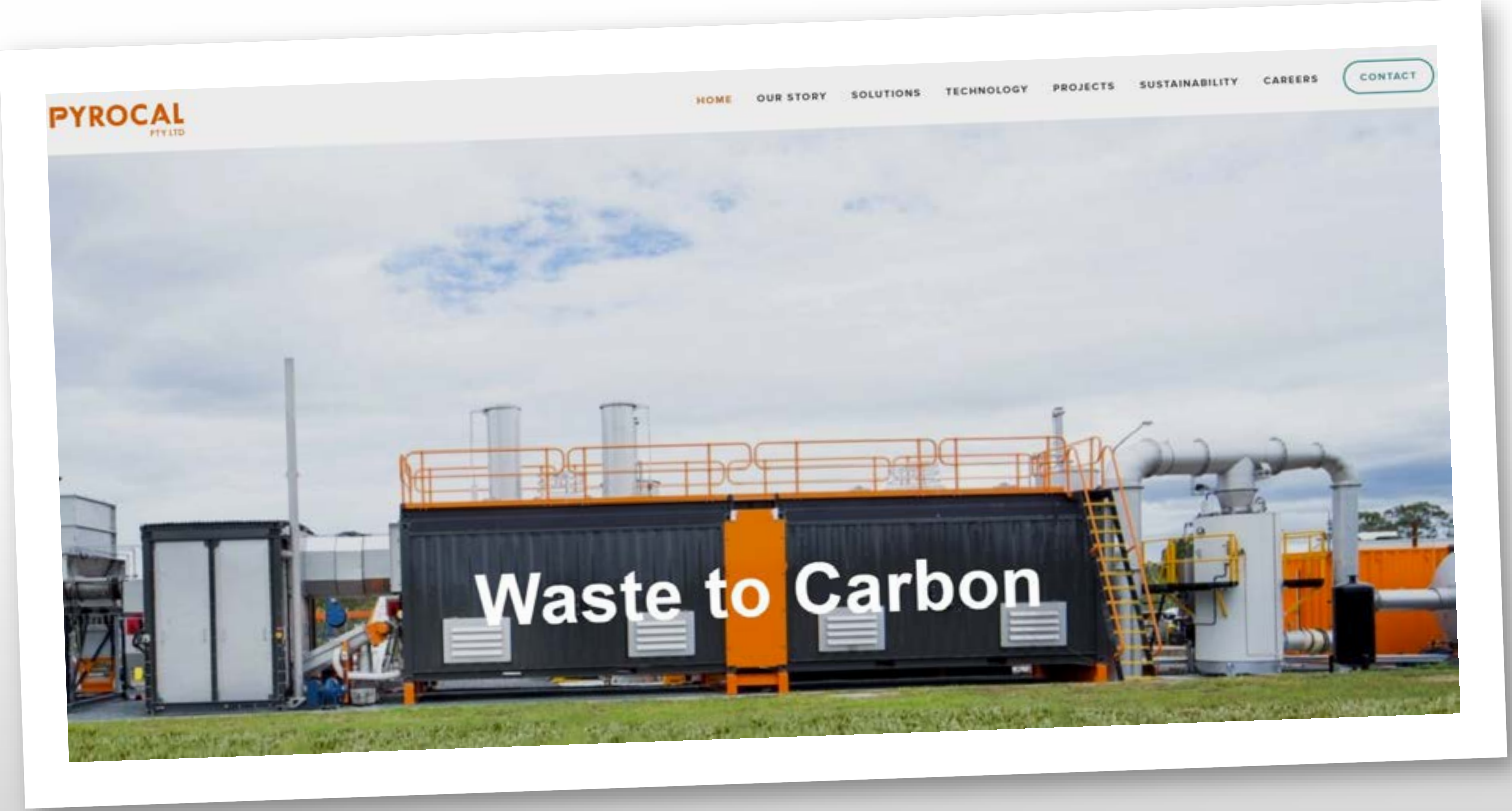
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TECHNOLOGY
PROJECTS
SUSTAINABILITY
CAREERS
CONTACT
Waste to Carbon


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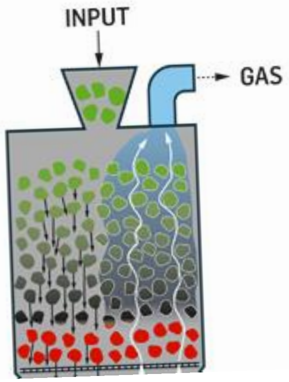
BIOMACON
DECARBO POWER
HEAT THAT SAVES THE CLIMATE

Carbon Terra®

Functionality



The Schottdorf method is neither gasification nor pyrolysis. The focus is on the production of pure biochar. The resulting gas is a by-product and can be used as an energy source.

Biogreen pyrolysis ⌄ Equipment ⌄ Applications ⌄ Pyrolysis products ⌄ About us ⌄ Contact ⌄

a part of VOW

Biogreen pyrolysis technology - Thermochemical conversion of biomass and waste

Pyrolysis process in mobile, containerised and fixed equipment

Biogreen® is innovative, patented pyrolysis process operating since 2003. Since more than a decade, our solution works for converting biomass, plastics, and waste into energy and useful products.

Biogreen pyrolysis process is based on electrically heated screw conveyor (Spirajoule®), designed for advanced thermal treatment in temperatures up to 800 degrees C and beyond. Processed product temperature is precisely controlled basing on the temperature settings. The dwell time of material inside Biogreen® reactor is regulated by screw rotation speed. Thermal conversion is performed in oxygen-free (pyrolysis) atmosphere in unique construction of equipment, which guarantees a constant quality of product obtained from the treatment.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BTG Bioliquids pyrolysis

Pyrolysis oil is a clean and uniform liquid that can be used as a sustainable alternative to fossil fuels for the production of renewable energy and chemicals. It is obtained through a process called fast pyrolysis, which transforms biomass into a liquid.


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Carbon Negative,
Community-Scale, and
Reliable Baseload Energy


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Biomass Pyrolysis Technology // Biochar production equipment
We are participating:
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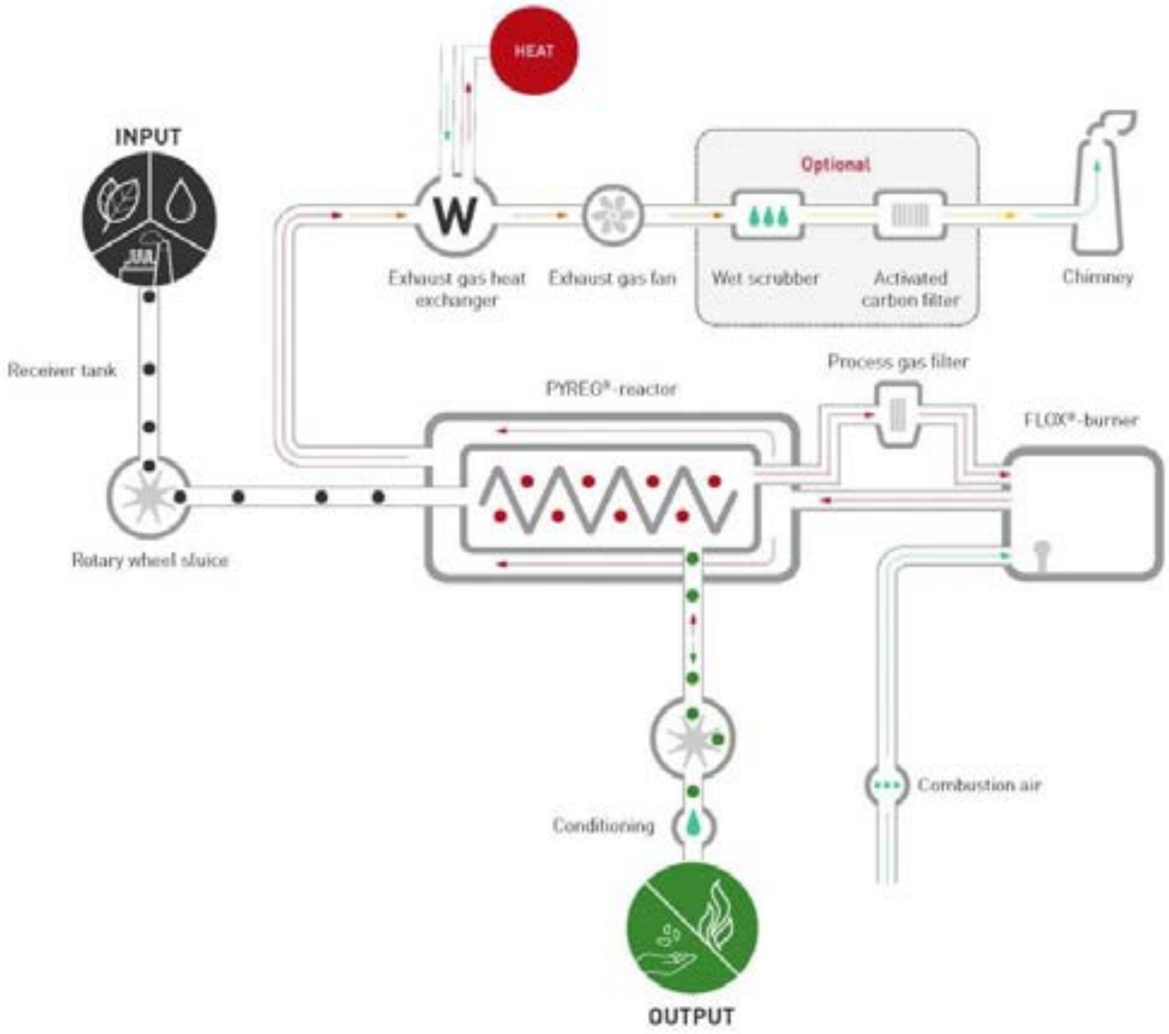
MUSK FOUNDATION
Kuva kuvassa
WORLD CLASS BIOCHAR PRODUCTION FACILITIES MADE IN FINLAND
Remove CO2 by converting waste biomass into energy
Industry-level biochar production technology
Suitable for biogas, pyrolysis oil, and clean energy production



HEAT
INPUT
Optional
Exhaust gas heat exchanger
Exhaust gas fan
Wet scrubber
Activated carbon filter
Chimney
Receiver tank
Process gas filter
PYREG®-reactor
FLOX®-burner
Rotary wheel sluice
Combustion air
Conditioning
OUTPUT

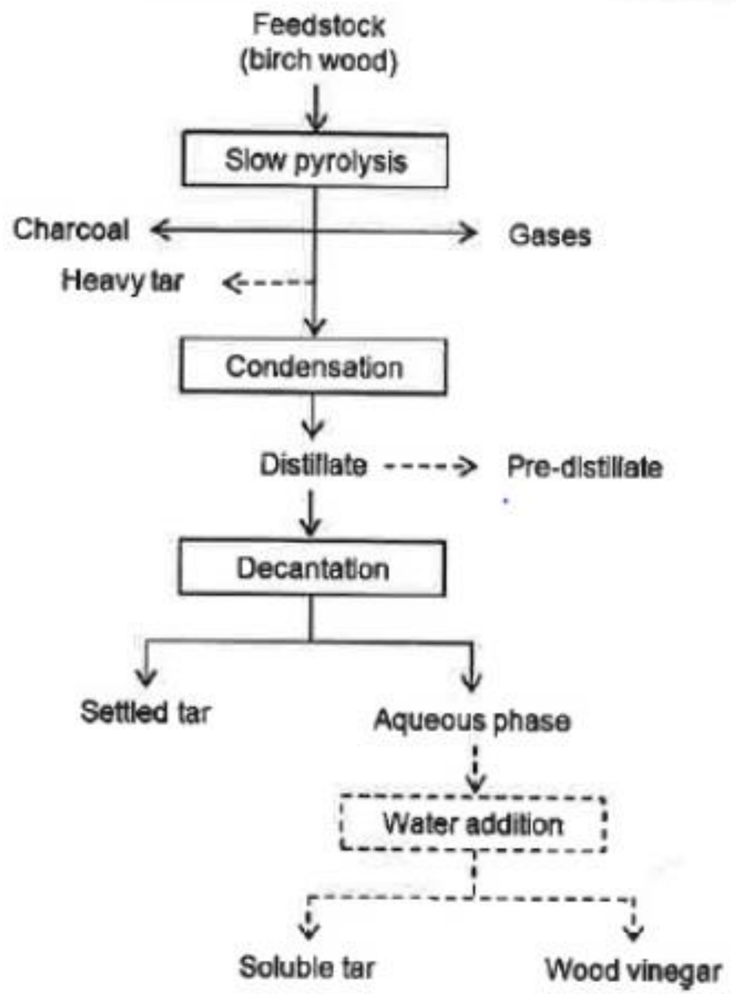

Feedstock
(birch wood)
Slow pyrolysis
Charcoal
Gases
Heavy tar
Condensation
Distillate
Pre-distillate
Decantation
Settled tar
Aqueous phase
Water addition
Soluble tar
Wood vinegar

Table 1:Share of products (Kantarelis et al. 2012)(Bridgwater 2007)

Method	Temp [°C]	Vapors res time	Char [wt %]	Liquid [wt %]	Gas [wt %]
Slow	400	Hours-days	30-40	25-30	25-35
Intermediate	500	5-30 s	25-30	40-50	25
Fast	500	1-2s	12-20	60-75	13-20

Table 2: Mass and energy balance of Dry Birch wt% (Fagernäs et al. 2014)

Yield from pyrolysis of Birch	Mass balance [wt%]	Energy balance [% of total]
Initial Feedstock, dry	100	100
Products total	94	95
Char	34	56
Liquids/distillate	42	16
Gases	18	23
Energy for process/losses	6	5

Table 3: Energy and product distribution of slow pyrolysis process (Rosas et al. 2015)

Products	Yield [wt%]	HHV [MJ/kg]	Energy [MJ/kg feedstock]	Exit temperature of products [^{o}C]	Heat losses [MJ/kg feedstock]
Char	40	12,8	5,16	322	1,67
Liquids	17	5,7	0,97	70	0,34
Gas	43	10,6	4,55	338	3,4

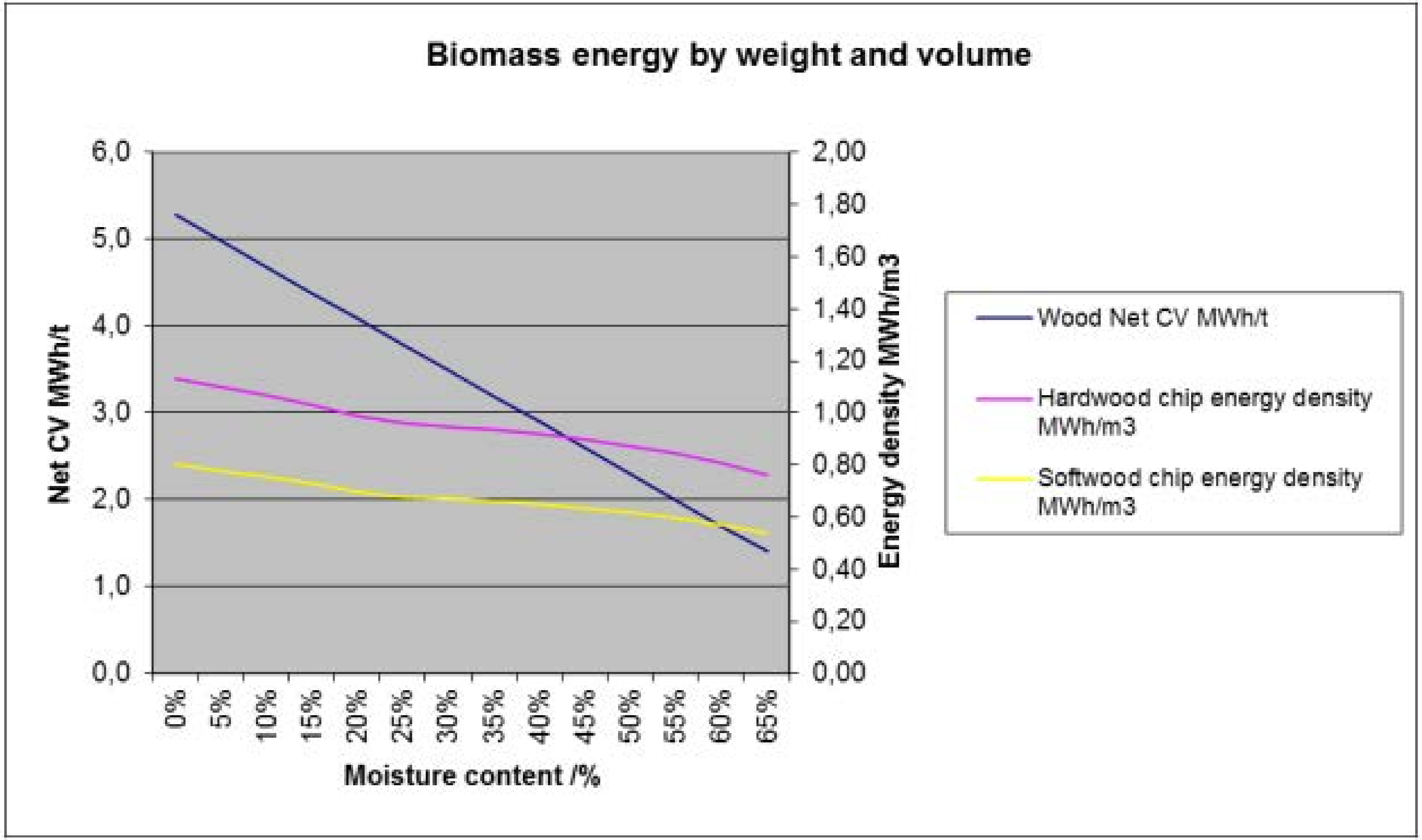


Figure 4: Energy and moisture content I biofuels (Biomass Energy Centre 2011)

Bioöljy

- Seos, jonka pääkomponentteja ovat hydroksyylialdehydit ja ketonit, sokerit, dehydrosokerit, karboksyylihapot ja eri fenoliyhdisteet.

Table 9: Temperature for chemical formation of compounds (Kantarelis et al. 2012)

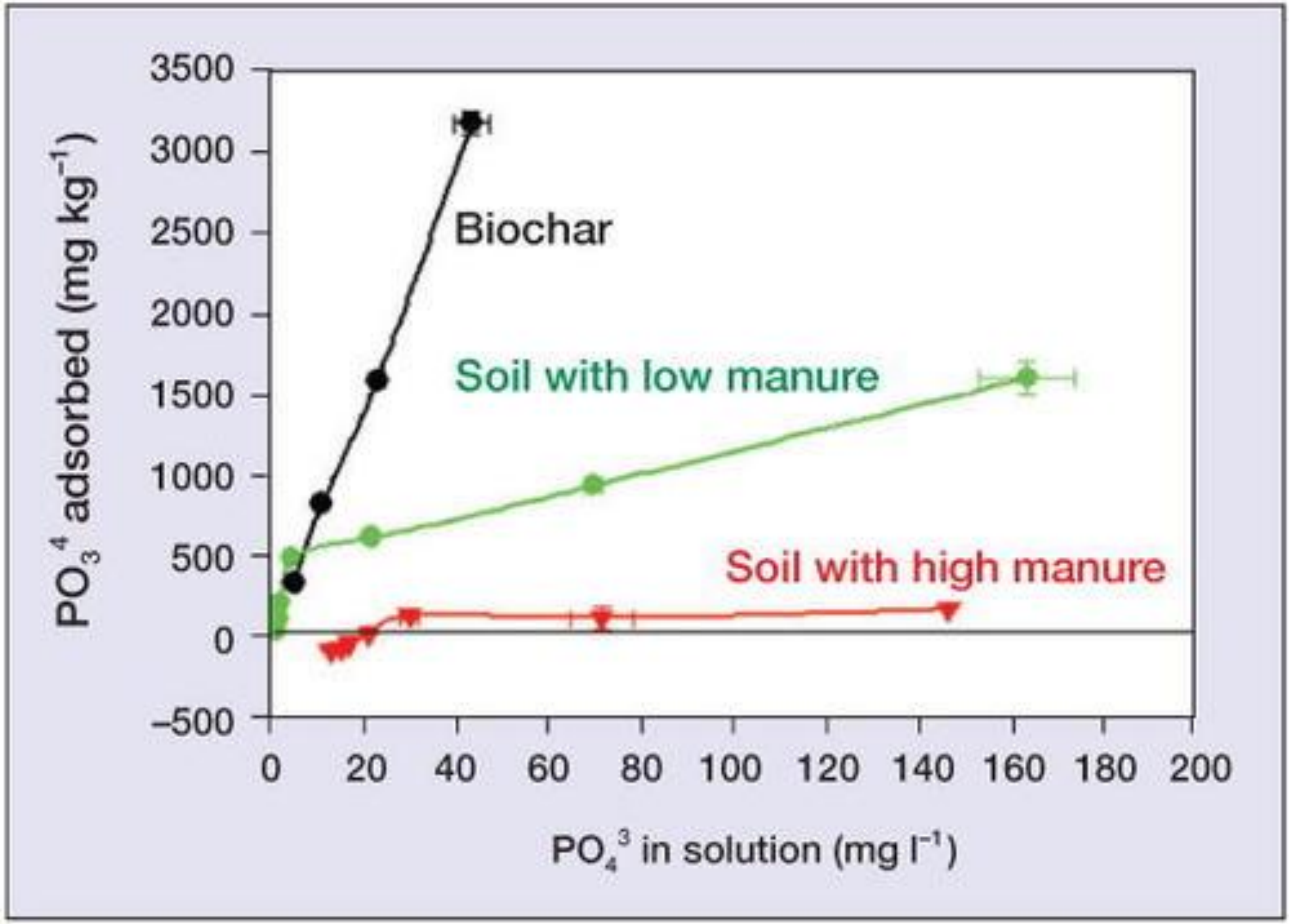
Mixed Oxygenates	Phenolic Ethers	Alkyl Ethers	Hetrocyclic Ethers	PAH	Larger PAH
400°*C*	500°*C*	600 °*C*	700 °*C*	800 °*C*	900 °*C*

Table 10:Typical values of wood derived bio-oil (Bridgwater 2007)(Kantarelis et al. 2012)

Moisture content [wt %]	20-30
pH	2,5
Specific gravity	1,20
C [wt %]	56
H [wt %]	6,5
O [wt %]	37,5
N [wt %]	0,1
Ash [wt %]	0
LHV [MJ/kg]	13-18

Table 7: Characteristics in char from slow pyrolysis of silver birch (Fagernäs et al. 2012)

	A1	A2	B	C
Moisture content [wt%]	1,3	4,9	2,8	0,9
Ash content [wt% DM]	0,8	1,4	1,2	0,9
Volatile matter [wt% DM]	19,6	19,9	18,4	17,1
Fixed carbon [wt% DM]	79,6	78,7	80,6	81,9
Heating value, calorimetric [MJ/kg]	33,2	33,4	33,8	33,4
Heating value effective [MJ/kg]	32,5	32,6	33,1	32,3
Carbon [wt% DM]	87,1	86,4	87,2	88,0
Hydrogen [wt% DM]	3,3	3,3	3,3	2,9
Nitrogen [wt% DM]	0,3	0,1	0,2	0,2
Sulfur [wt% DM]	0,02	0,01	0,02	0,02
Oxygen [wt% DM]	9	9	8	8



3500
3000
2500
2000
1500
1000
500
0
–500
0
20
40
60
80
100
120
140
160
180
200
PO3 4 adsorbed (mg kg-1)
PO4 3 in solution (mg l-1)
Biochar
Soil with low manure
Soil with high manure

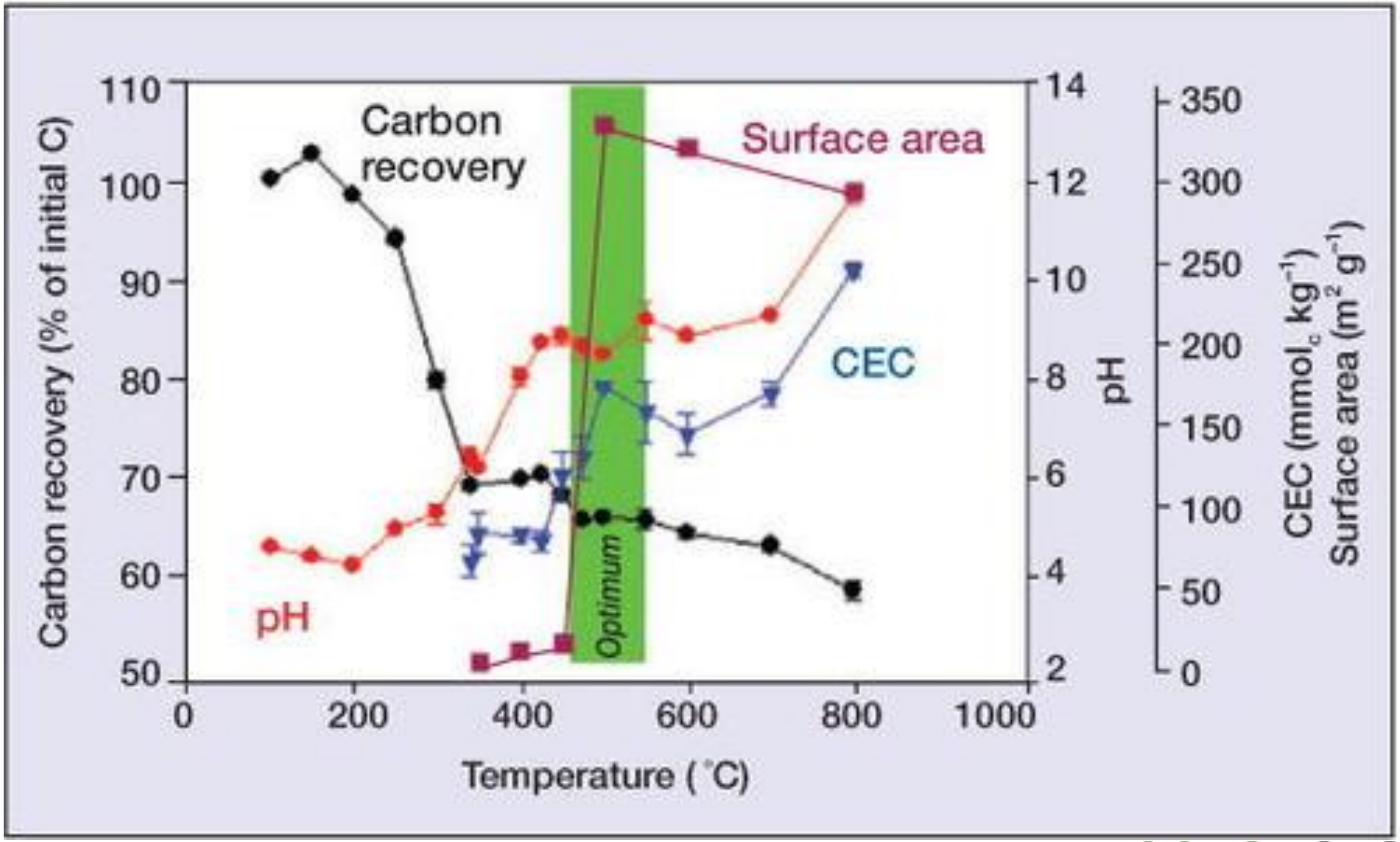

Carbon recovery
Surface area
CEC
pH
Optimum
Carbon recovery (% of initial C)
pH
CEC (mmol$_c$ kg^{-1})
Surface area (m^2 g^{-1})
Temperature (°C)
110
100
90
80
70
60
50
0
200
400
600
800
1000
14
12
10
8
6
4
2
350
300
250
200
150
100
50
0

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Table 12: Gas composition from slow pyrolysis of Beech wood chips (D'Alessandro et al. 2013)

Methane [vol %]	9,95
Hydrogen[vol %]	2,21
Carbon monoxide [vol %]	41,23
Carbon dioxide [vol %]	40,60
Nitrogen [vol %]	6,01
LHV [MJ/kg]	6,17

Table 14: Cost of slow pyrolysis and biochar applications (Shackley et al. 2011)

Stage in pyrolysis system	Cost of biochar [€/ ton]
Virgin Feedstock	76-347
Non-virgin Feedstock	0
Transport of feedstock	11-62
Capital cost of power plant	63-141
Operational costs	13-167
Storage of biochar	10-21
Transport of biochar	0-27
Application of biochar to soil	7


Renewable and Sustainable Energy Reviews

Process development status of fast pyrolysis technologies for the manufacture of renewable transport fuels from biomass

Highlights

- Comprehensive review on current status of biomass fast pyrolysis into renewable fuels.
- Summary on the progress on semi-commercial conversion technologies.
- Detailed discussion of available technologies with focus on the commercial readiness of the thermal and catalytic pyrolysis.
- Key impediments in biomass conversion technologies at industrial scale.

Slow pyrolysis in Brista

AN EVALUATION OF HEAT AND BIOCHAR PRODUCTION IN SWEDEN

ERIK JONSSON

Lappeenrannan teknillinen yliopisto

Teknillinen tiedekunta

Energiatekniikan koulutusohjelma

BH10A0201 Energiatekniikan kandidaatintyö ja seminaari

Bioöljy ja pyrolyysi

Työn tarkastaja: Esa Vakkilainen

Työn ohjaaja: Kari Luostarinen ja Esa Vakkilainen

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