

# Biochar as a product from FlexSNG



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for Energy Research  
by EDF and KIT



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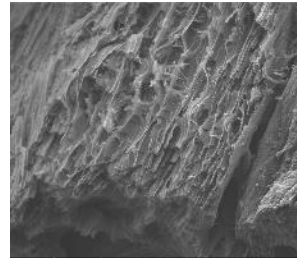
# What is Biochar ?

“Biochar is defined as **carbonized** biomass obtained from sustainable sources and sequestered in soils to sustainably enhance their agricultural and environmental value under present and future management” (International Biochar Initiative)

However, biochar is often used synonymous with charcoal, but also mixed with:  
black carbon, pyrogenic carbon, activated carbon, soot, torrefied biomass,  
hydrochar, HTC coal, wet charcoal, ash, ...

For FlexSNG

=> biochar is the “solid carbon-rich material” leaving the gasifier



# Biochar applications

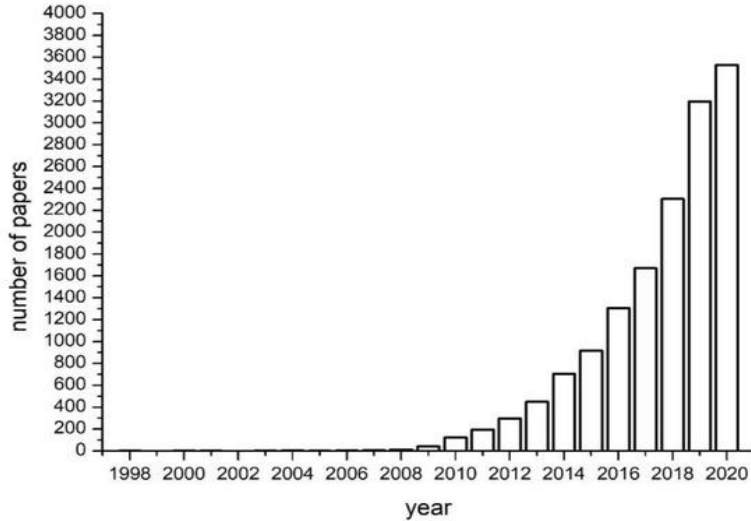
Besides energy, many other uses:

- Animal fodder additive
- Composting
- Soil amendment
- Additive for biogas productions
- Biochar for building material
- Removal of pollutants in water and gases
- Biogenic carbon for FC, batteries, super-conductors
- Replacement of coke for steel industry
- Composite materials for organic materials



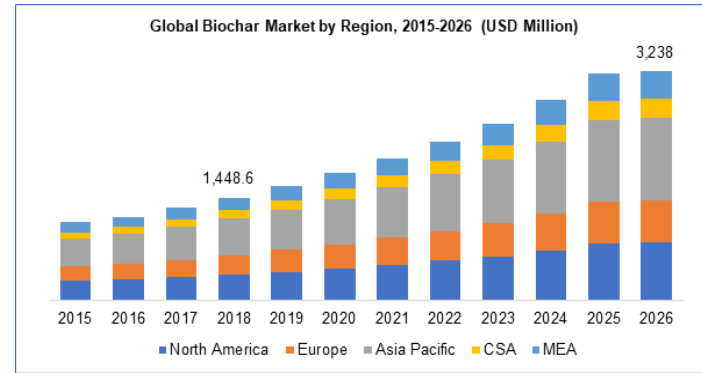
Source: European Biochar Industry Consortium (<https://www.biochar-industry.com/>)

# Growing interest on Biochar

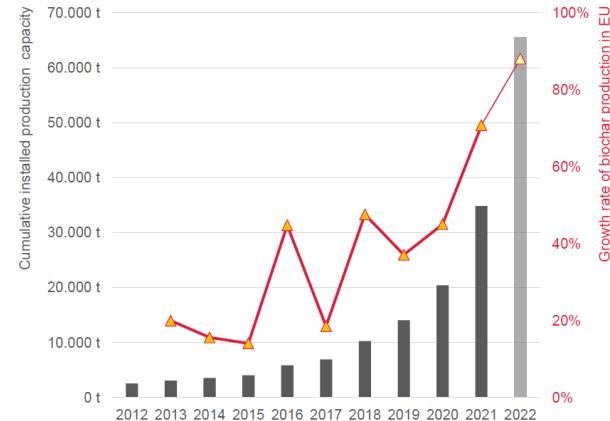


Conte, P., Recent Developments in Understanding Biochar's Physical-Chemistry; *Agronomy* 2021, 11(4), 615

=> In science as well in industry



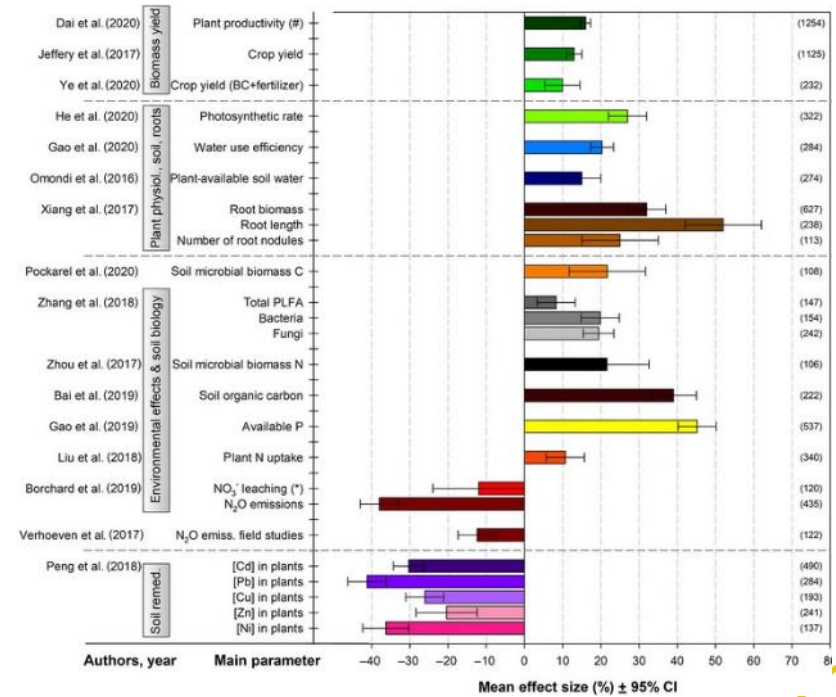
Source: Polaris Market Research and Consulting; New York (2019)



European Biochar Market Report 2021/2022; EBI; (3/2022)

# Biochar for agriculture?

- Controversial discussions over the last decade about it's real effects
- However, many studies and meta studies confirm a general positive effect
- Qualitative and quantitative effects depend on:
  - soil characteristics
  - plants and crops
  - nutrients and fertilizers
  - biochar characteristics

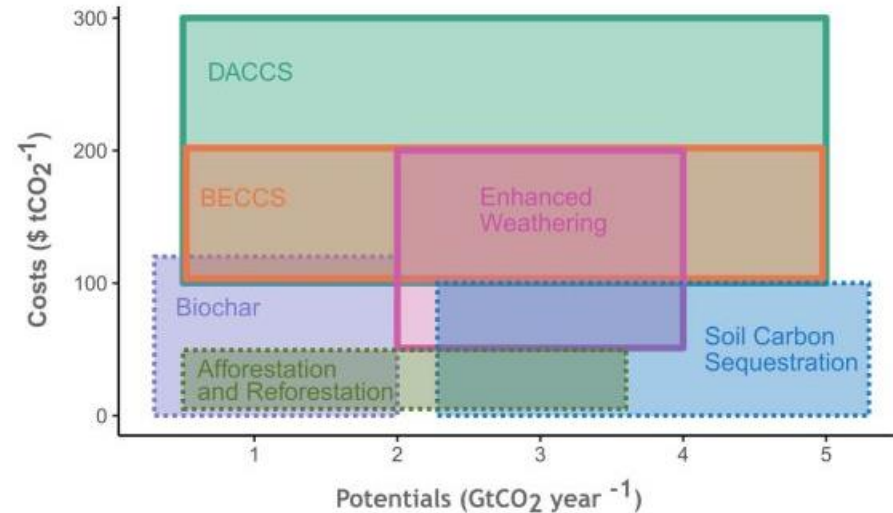


Schmidt, et al (2021). Biochar in agriculture – A systematic review of 26 global meta-analyses. *GCB Bioenergy*, 13, 1708– 1730.  
<https://doi.org/10.1111/gcbb.12889>

# Biochar for CDR – A Negative Emission Technology

- Biochar considered as one promising and cheap Negative Emission Technology by IPCC
- Positive side effects:
  - Bioenergy as by-product
  - Low additional water demand
  - Increase plant growth
  - Nutrient recovery
  - Reduced N<sub>2</sub>O emissions
- Potential risks
  - Land use
  - Maximum capacity of soils
  - Liability of sequestered carbon

Estimated costs and 2050 potentials



de Coninck, H., A. et al; In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*; in [Masson-Delmotte, V., P., et al (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 313-444, doi:10.1017/9781009157940.006.

# Biochar – Characteristics

Biochar properties depend on:

- process conditions
- feedstock

Key characteristics:

- (fixed) carbon content
- pollutants & impurities content

As well

- Surface area & pore characteristics
- Water holding capacity
- Cation Exchange capacity
- pH value
- Particle size distribution
- Electrical conductivity

	Bark	Wood
<b>C<sub>org</sub></b>	82 wt-%	88 wt-%
<b>H/ C<sub>org</sub></b>	0,12	0,20
<b>O/C<sub>org</sub></b>	0,04	0,07
<b>VOCs</b>	5-15%	10-15%
<b>HHV (waf)</b>	30-31 MJ/kg	31 MJ/kg
<b>Heavy metals</b>	< IBI & EBC thresholds	
<b>pH</b>	10	11,2
<b>Bulk density</b>	300 g/dm <sup>3</sup>	280 g/dm <sup>3</sup>
<b>Water content</b>	<2 wt-%	<2 wt-%
<b>WHC</b>	105%	110%
<b>EC</b>	1-2 mS/cm	4-5 mS/cm
<b>Spec. surface S<sub>BET</sub></b>	250-350 m <sup>2</sup> /g	270 m <sup>2</sup> /g
<b>PAHs</b>	6 mg/kg	38 mg/kg
<b>Nutrients (wf)</b>		
<b>N</b>	0,66 wt-%	0,25 wt-%
<b>P</b>	0,38 wt-%	0,50 wt-%
<b>K</b>	0,94 wt-%	1,10 wt-%
<b>Ca</b>	4,20 wt-%	1,38 wt-%
<b>Mg</b>	0,52 wt-%	8,10 wt-%
<b>Fe</b>	0,32 wt-%	0,71 wt-%

# Which biochar for which market?

	Agricultural		Construction	Activated biochar
	Animal feed	Soil amendment		
Characteristics	No/ low pollutants Carbon content Porosity Morphology	Low pollutants Carbon content Porosity Morphology	Depending on application High mineral content possible	Adsorption capacity (adjustable) Morphology Porosity Functional groups Low mineral content
Regulations	EU feed regulation National Certification	EU fertilizer regulation + country-specific (e.g. D�MV)	Existing construction regulations	„Just“ industry requirements
Possible feedstocks	Pure biomass Clean waste wood No wastes	Pure biomass Clean waste wood Agricultural residues No wastes	Biomass & Residues Biowastes All waste woods Sewage sludge	All, but low mineral content
Maturity	High	High	Close to market	R&D
Market outlook	Stable	Increase	huge	growing need for water purification
Expected price range	medium	medium	Low to high (quality depending)	high



# Thank you!



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