



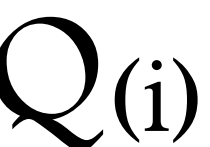
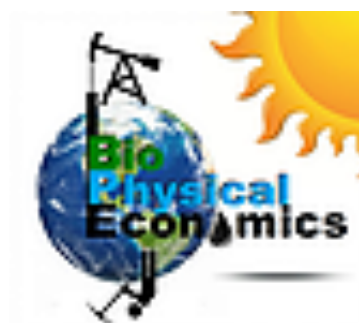
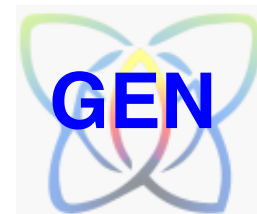
Biochar and Bioenergy

Colorado State University
July 3, 2019

CARBON MATH

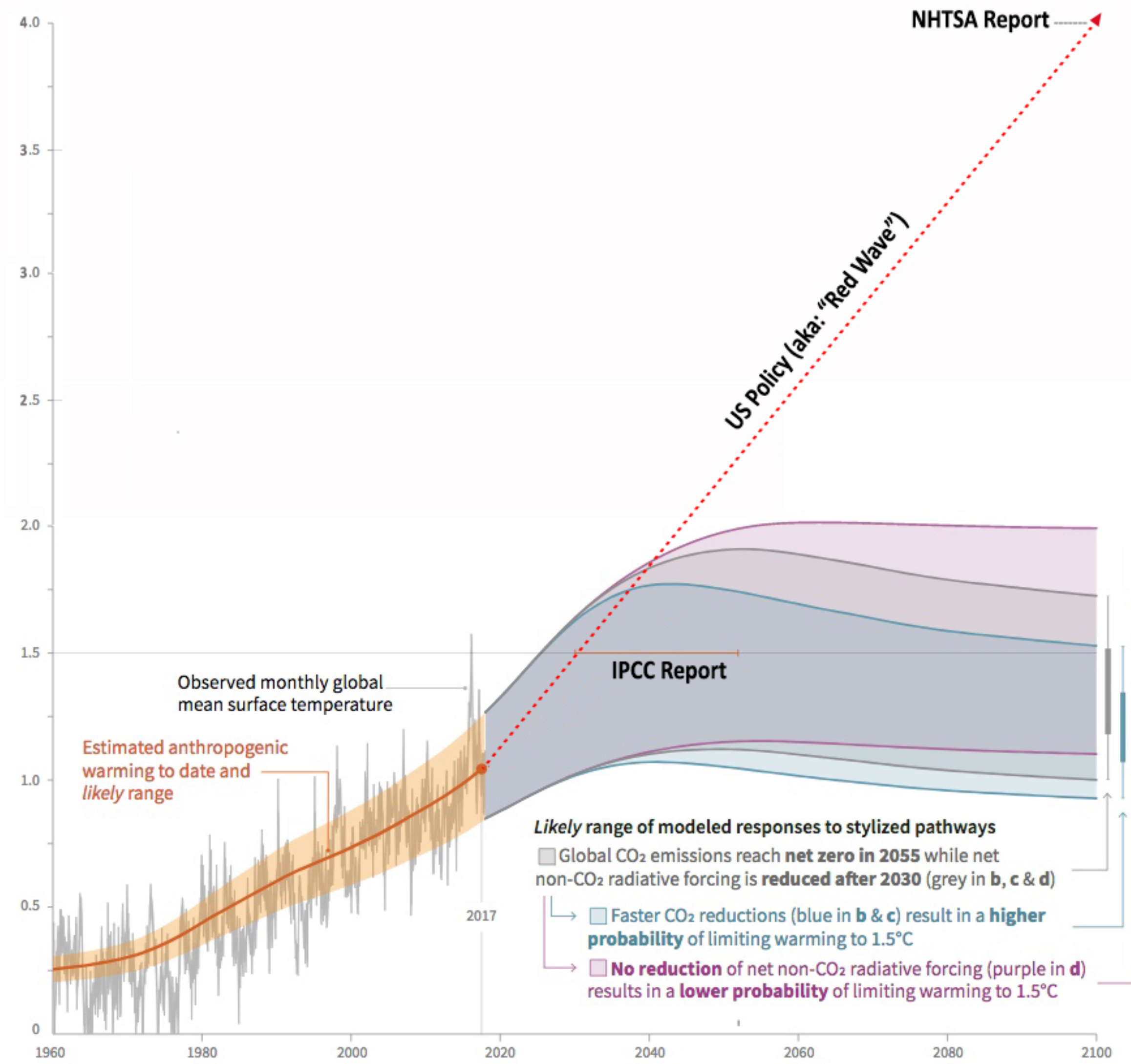
Kathleen Draper
Ithaka Institute for Carbon Intelligence

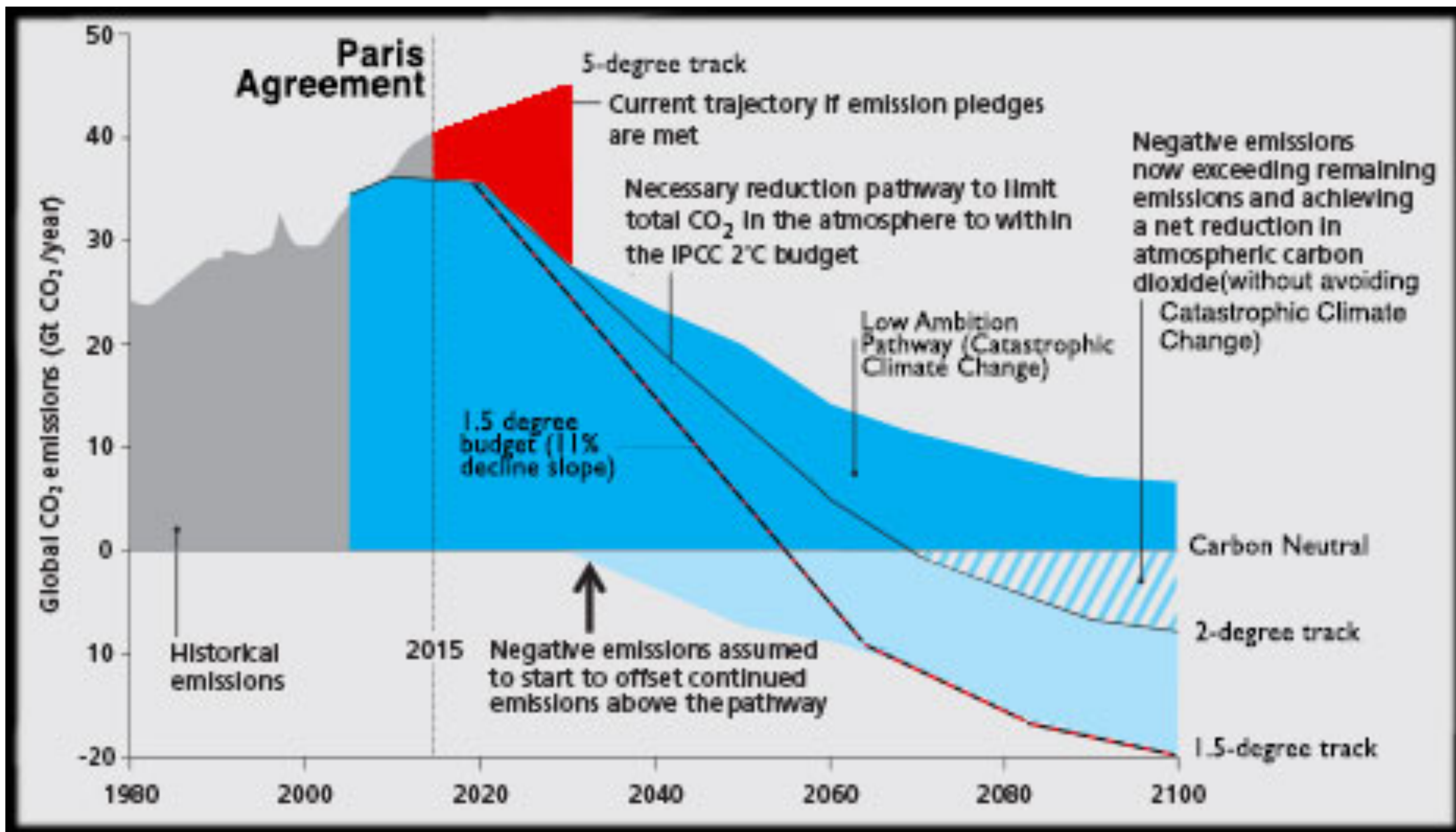
Albert Bates
*Global Village Institute
for appropriate technology*



b) Projected global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways

Global warming relative to 1850-1900 (°C)

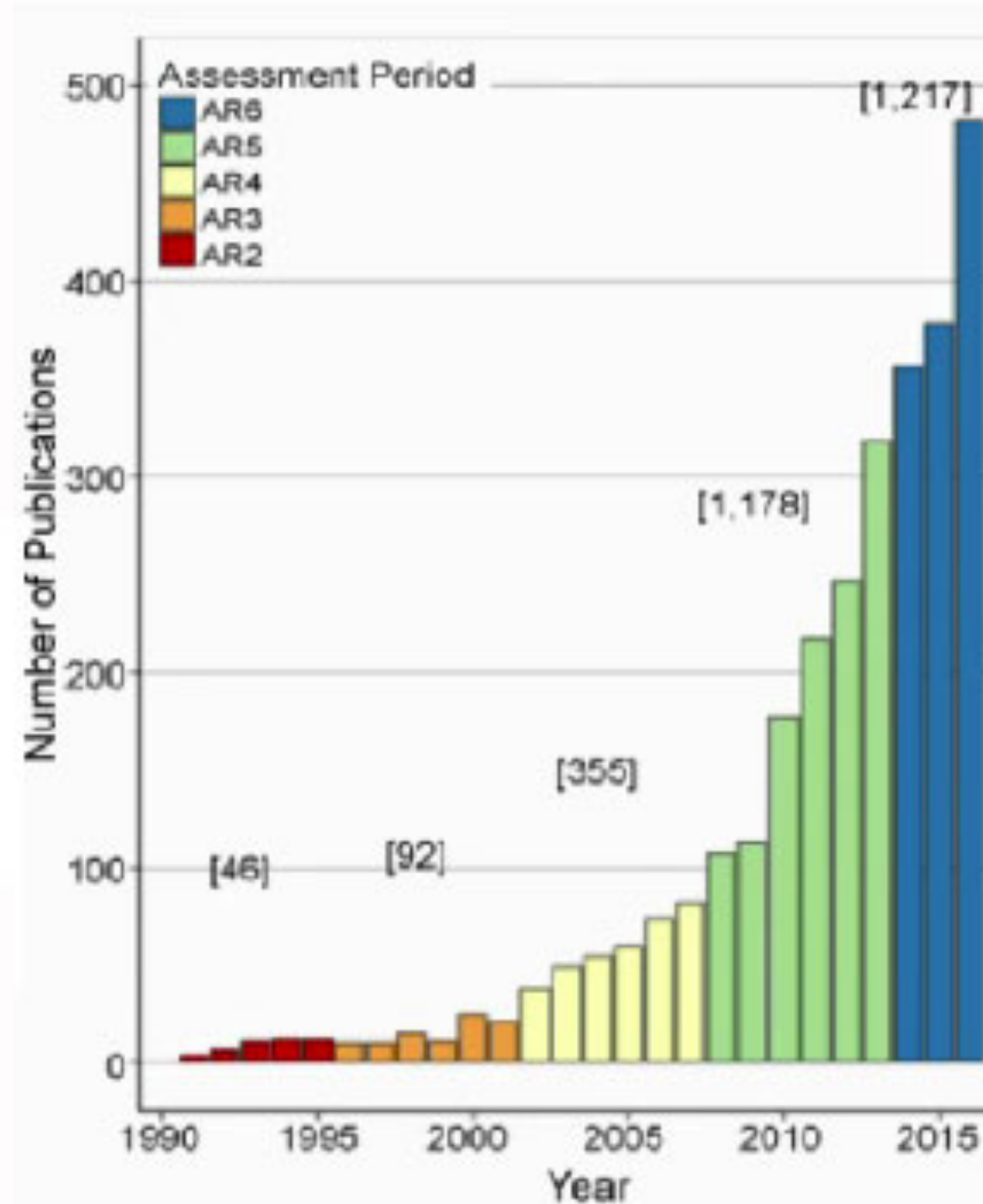




NEGATIVE EMISSIONS TECHNOLOGIES

after FUSS 2018

Number of peer-reviewed articles
on Negative Emissions Technologies
1990-2015

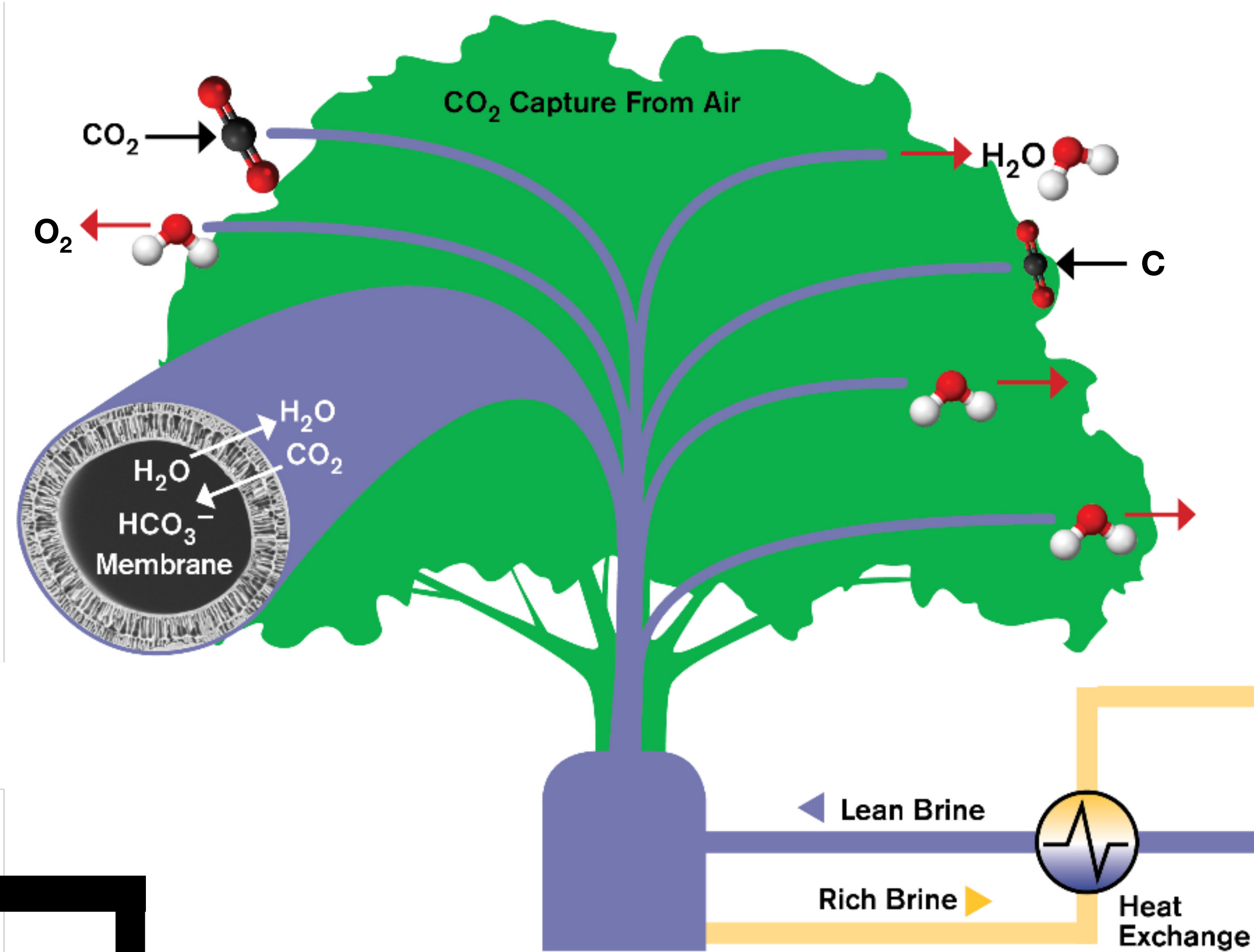


- changes to land use management
- accelerated weathering
- marine flora
- bioenergy with carbon capture and storage (BECCS)
- direct air capture (DAC)

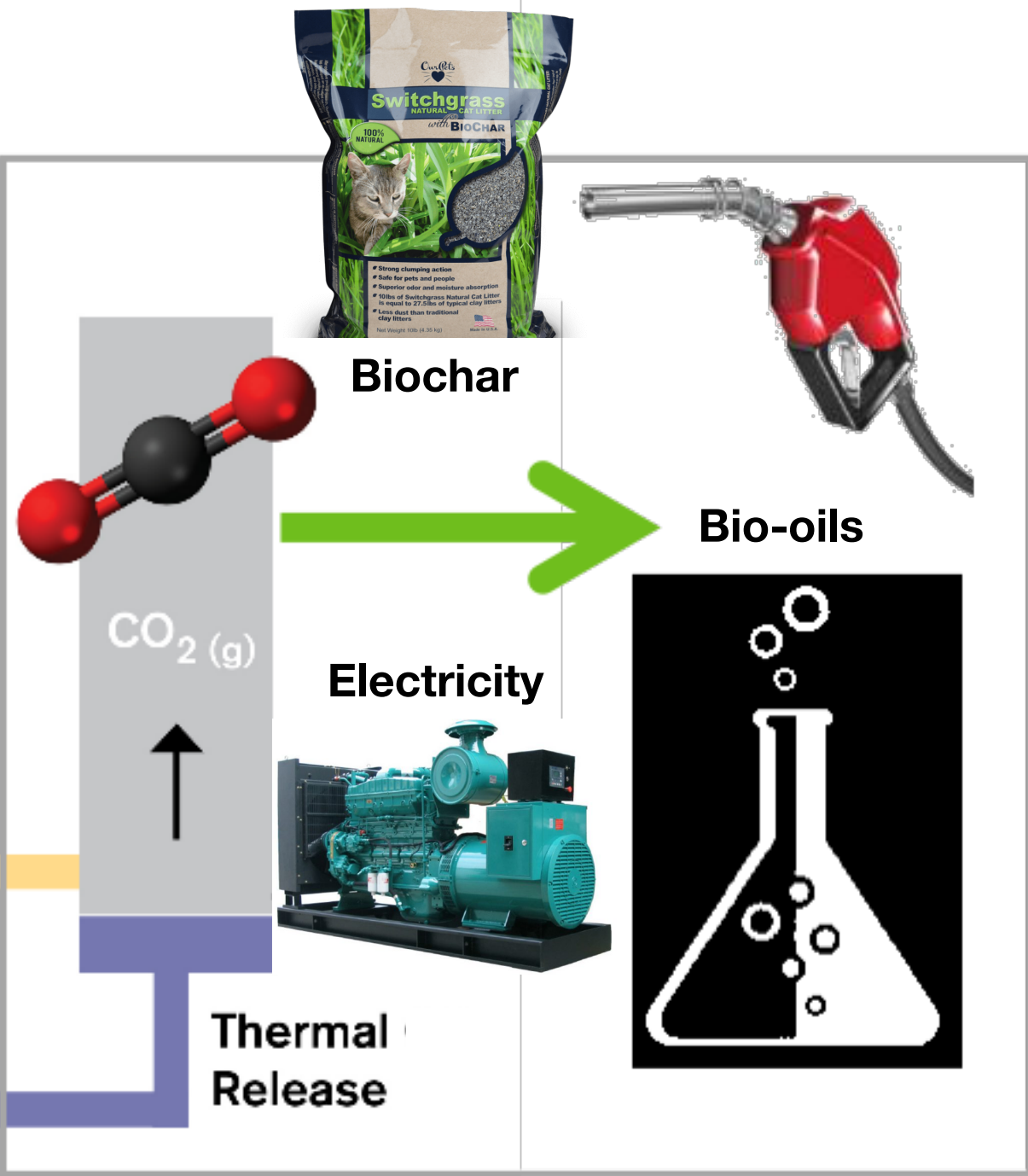
Direct Air Capture and Carbon Storage (DACCS)



Artificial Tree



Actual Tree



Carbon Cascades

Deep Geological Storage

What is Biochar?

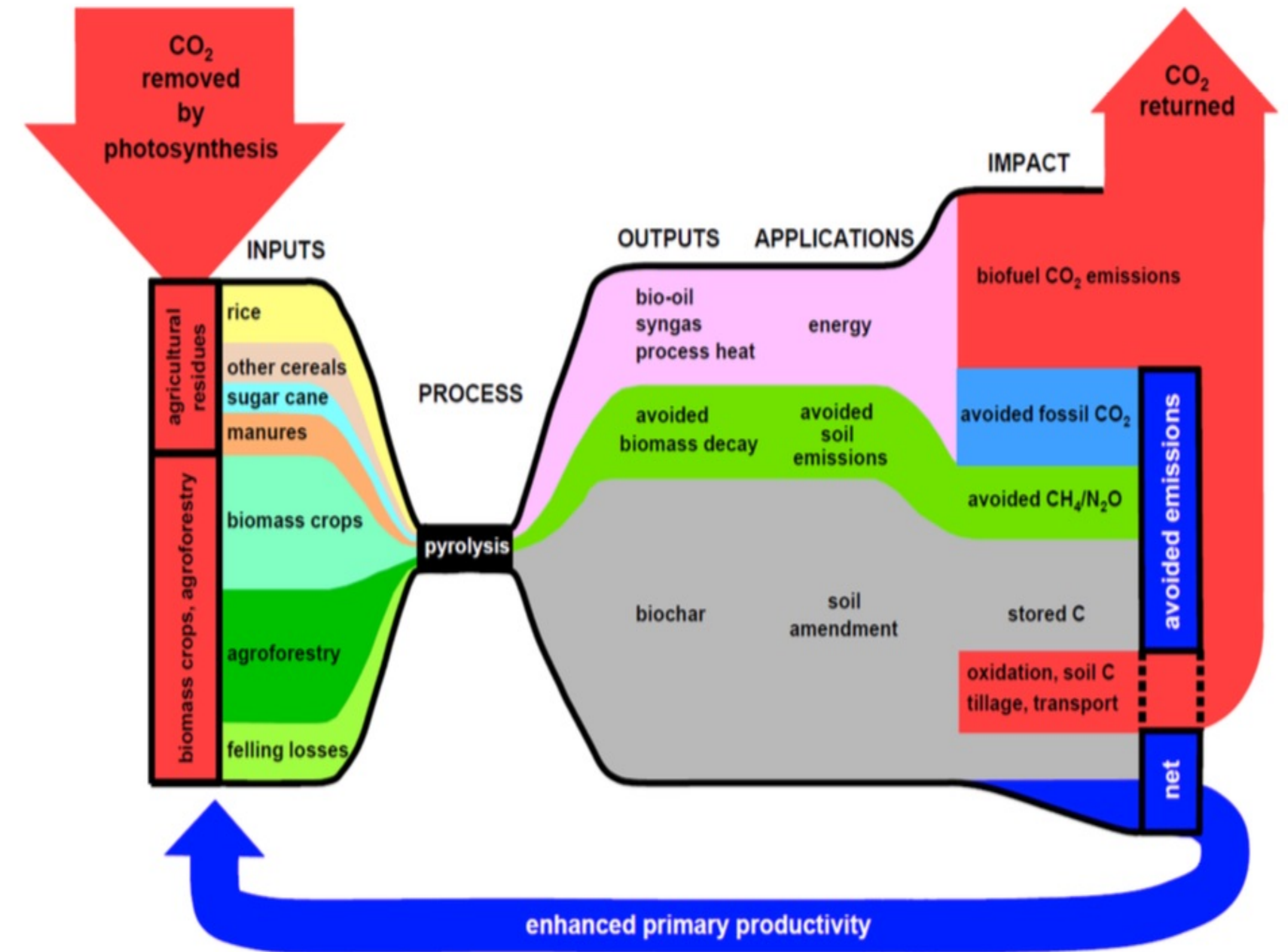


Biochar is using fire to remove carbon from the atmosphere, turning it into coal and burying it in the ground for thousands of years.

Biochar supports food, water, shelter and financial security.

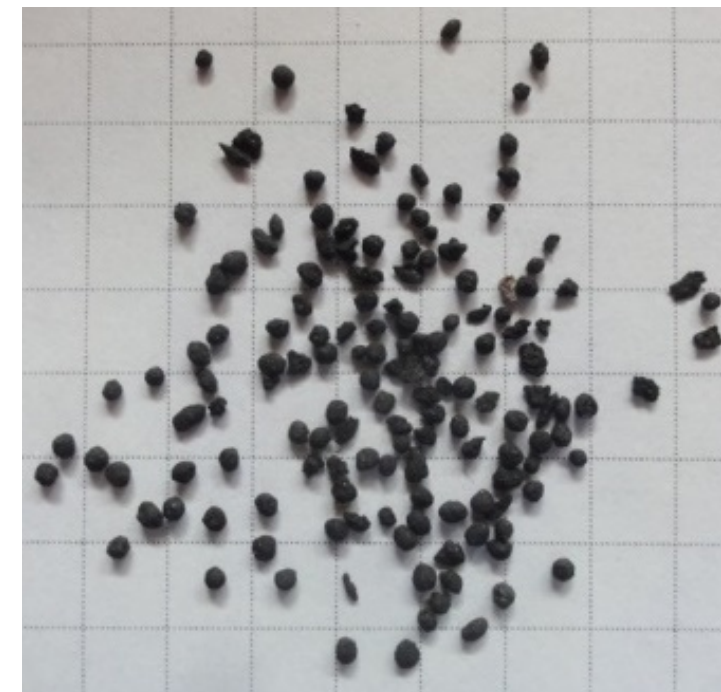
Summary of Biomass Availability Scenarios

Feedstock	Biomass availability in scenario (Pg yr ⁻¹)					
	Alpha		Beta		MSTP	
	DM	C	DM	C	DM	C
Cereals excluding rice	0.17	0.07	0.29	0.13	0.42	0.18
Rice	0.52	0.22	0.60	0.25	0.67	0.28
Sugar cane	0.20	0.09	0.24	0.11	0.27	0.13
Manure	0.31	0.10	0.45	0.14	0.59	0.19
Biomass crops	0.63	0.30	0.94	0.60	1.25	0.60
Harvested wood	0.05	0.03	0.13	0.07	0.21	0.10
Forestry residues	0.29	0.14	0.29	0.14	0.29	0.14
Agroforestry	0.13	0.06	0.70	0.34	1.28	0.62
Green waste	0.01	0.004	0.05	0.02	0.07	0.04
Total	2.3	1.0	3.7	1.6	5.1	2.3



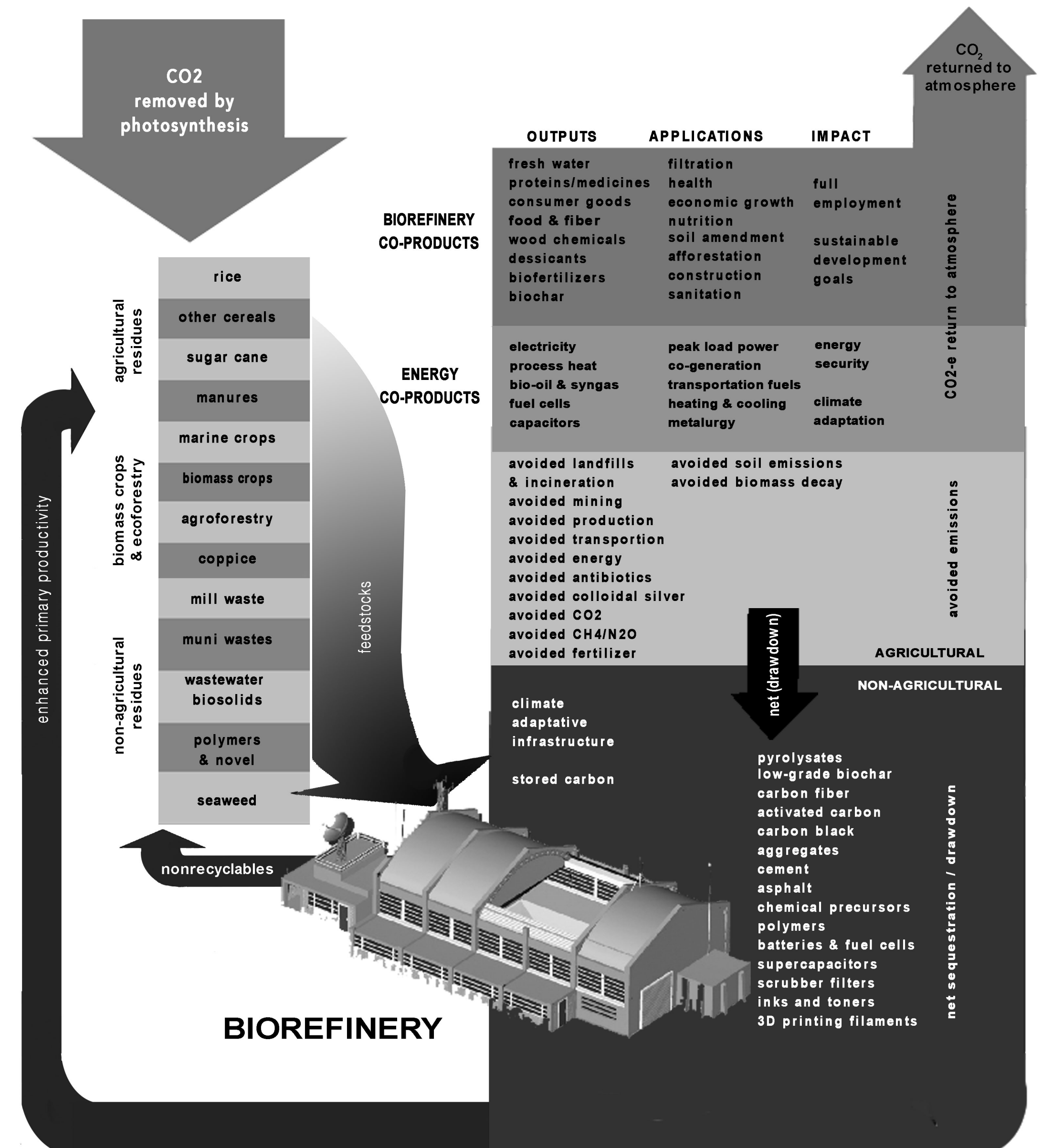
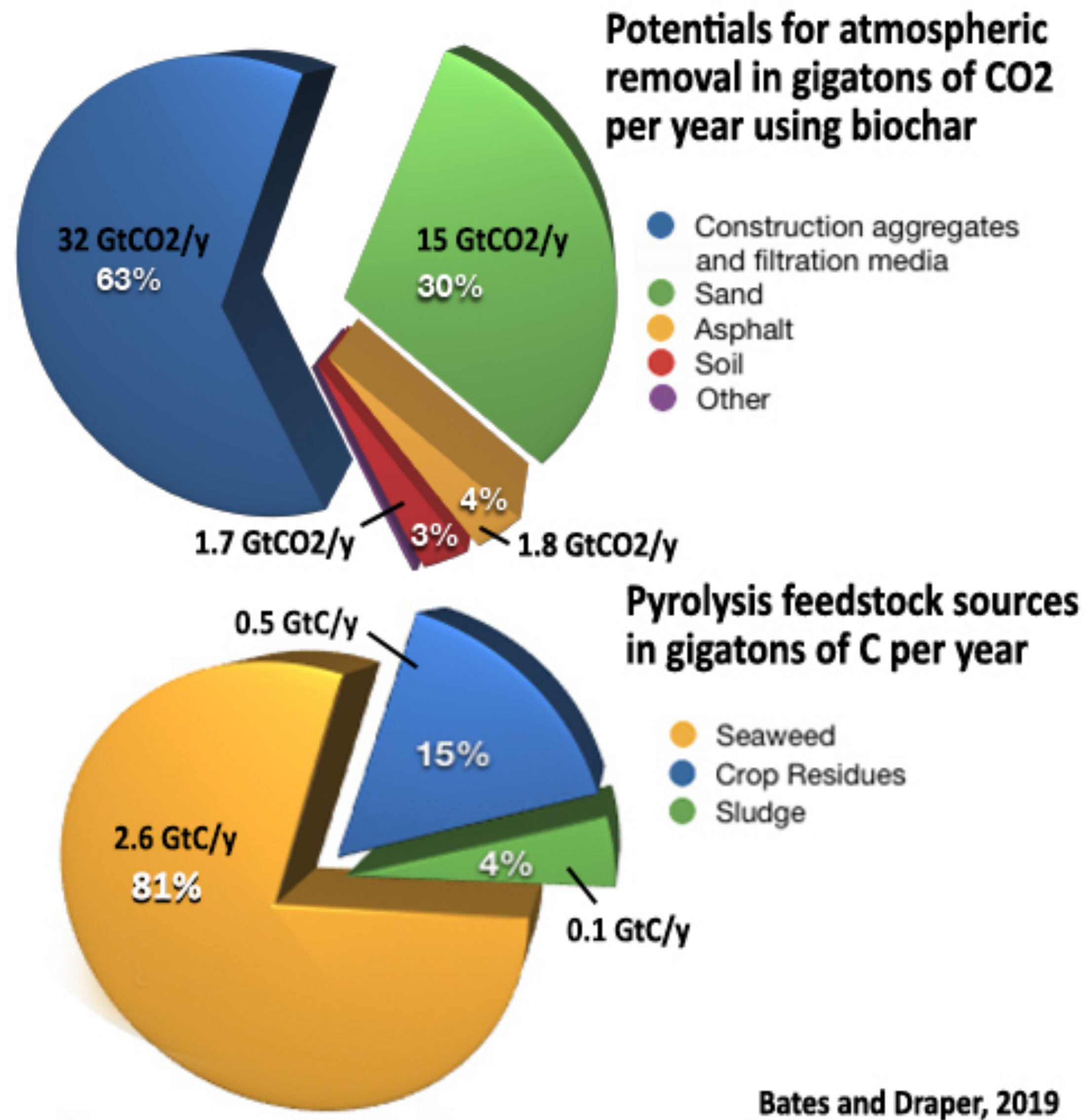
Woolf-Amonette 2010

Biochars are to be made “Fit for Purpose”



Courtesy T.A. Miles





NEW ECONOMY

“It’s not the Industrial Revolution but its a carbon copy.”

Who buys Biochar? Where are present markets?



Agriculture, Retail Garden, Landscape, Turf, Horticulture

Farm and Consumer products

Biochar, Compost

Composted biochar (5%-20% biochar)

Biochar-Based Compound Fertilizers (15%-25% biochar)

Biotic Soil Amendments(biochar + organics+ minerals and biologicals)

Granulated products for hydro-seeding

Environment, Remediation, Erosion Control

Forest Fuels and Reforestation

Sewage Treatment, Solids and Odor

Mine reclamation, Oilfield remediation, Filtration

Stormwater filtration, water treatment

Non-soil carbon product

animal feed, building products, odor control, food



Courtesy T.A. Miles



Do the Math



CURRENT Anthropogenic CO₂-e/y in gigatonnes: 40

Construction aggregate displacement

Global cement production by weight (2017): 53

Convert 20% to biochar: 10.6

With 82% C content: 8.7

CO₂-e drawdown potential: **31.9**

CO₂-e emissions reduction from cement production: 3.8

Sand displacement

Global sand mining: 15

Replace one third with biochar: 5

With 82% C content: 4.1

CO₂-e drawdown potential: **15**

CO₂-e abated from sand mining & transport: unknown

Asphalt displacement

Global asphalt production by weight (2017): 2.5

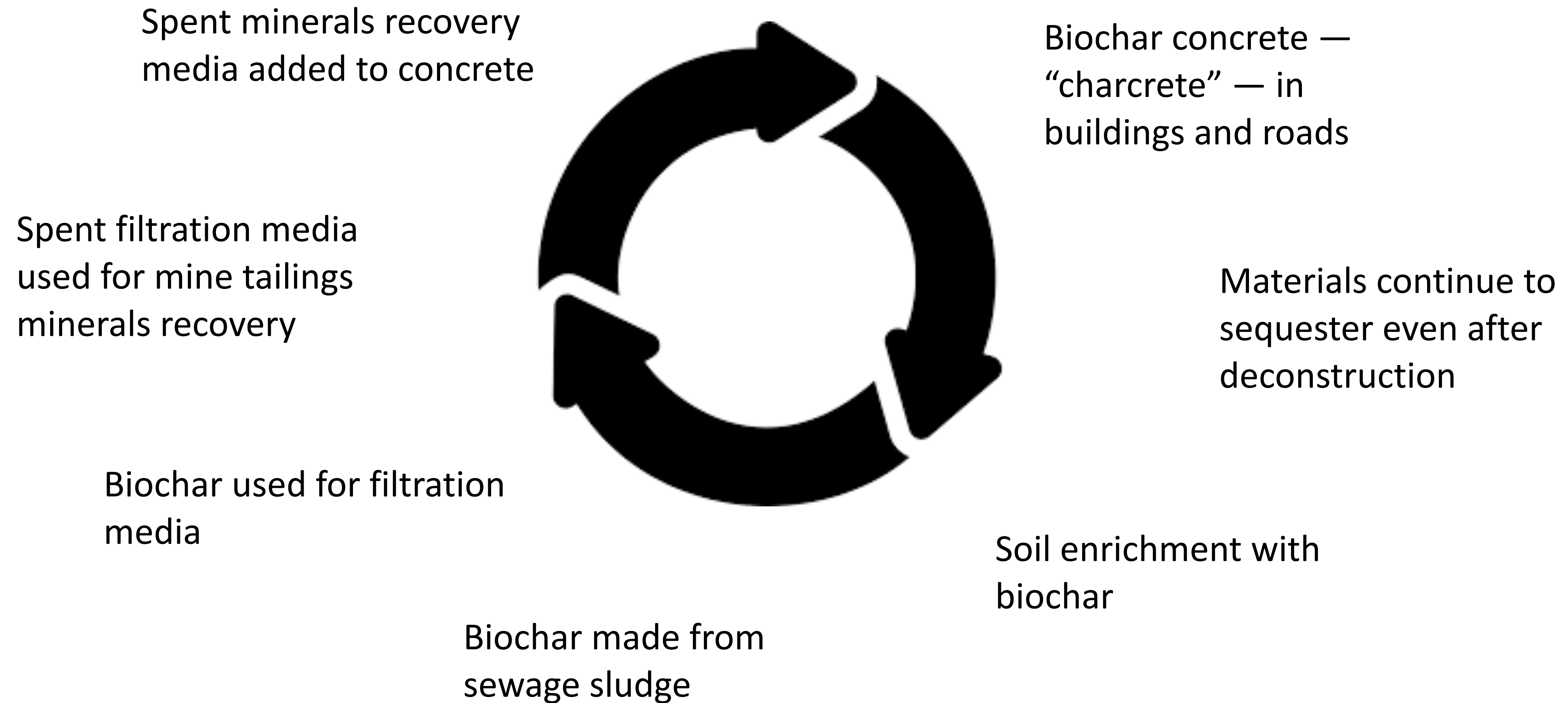
Convert 20% to bio-oils, biochar, or pyrolysates: 0.5

CO₂-e drawdown potential: **1.8**

CO₂-e emissions reduction from avoided mining: unknown

POTENTIAL CO₂-e/y drawdown in gigatonnes: 48.7

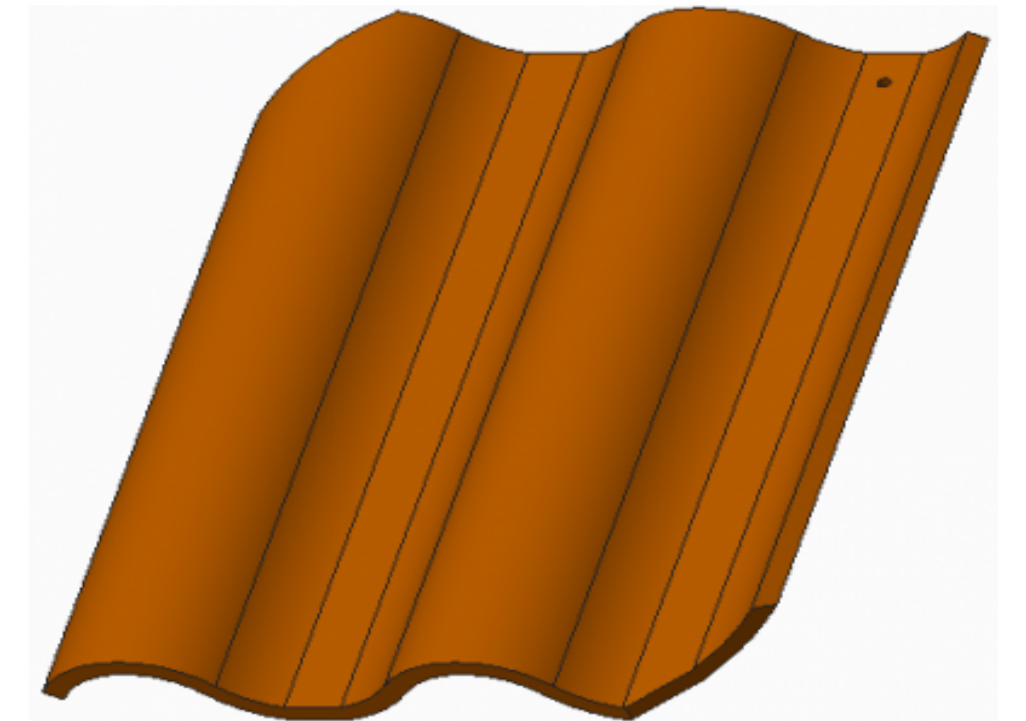
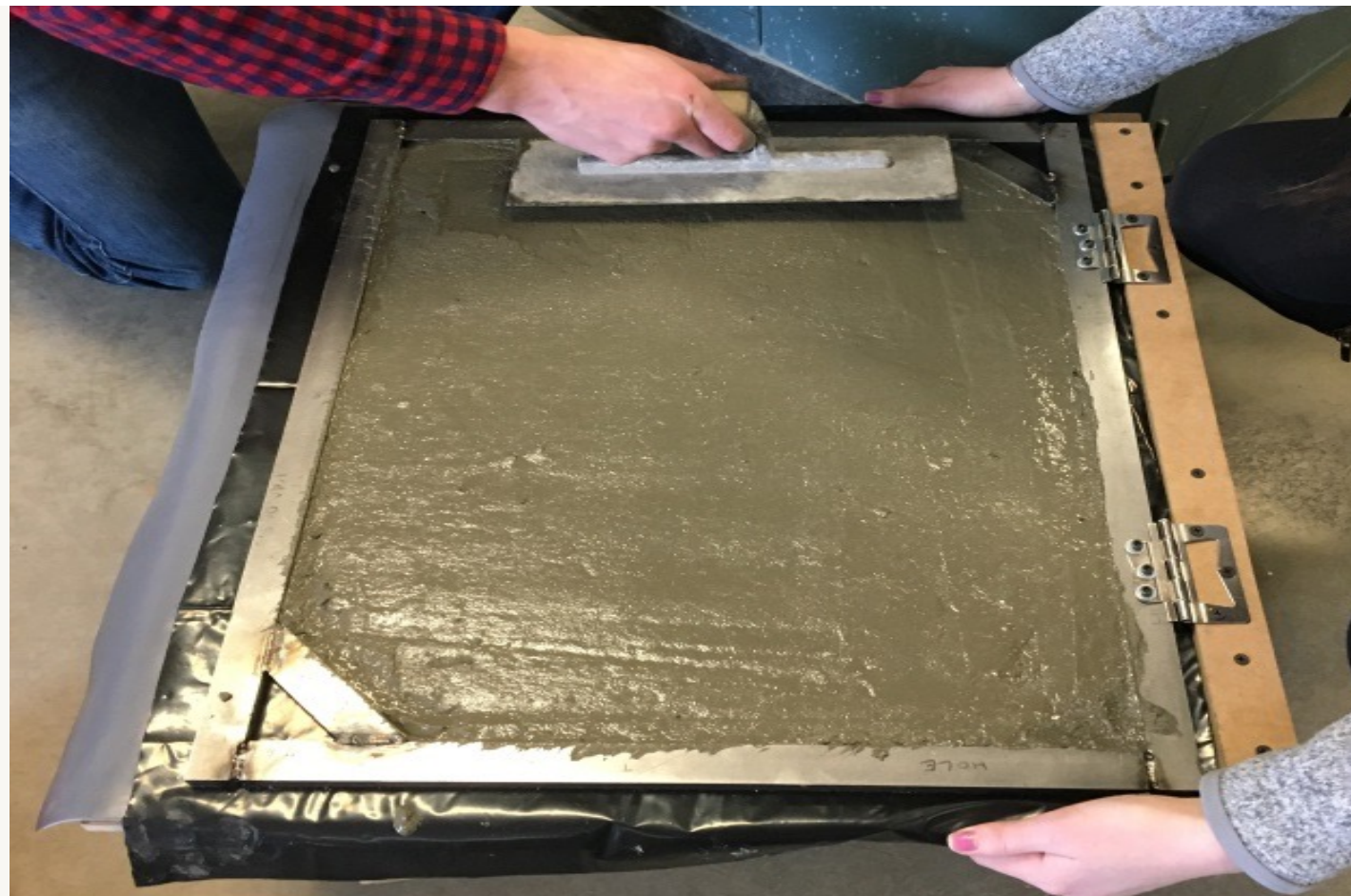
Cascaded Construction: A Fresh Foundation



Nicaragua Biochar Roof Tiles Project



- Mix all dry ingredients thoroughly
- Add water as needed
- Add concrete or polymer mix to flat tile mold
- Vibrate to remove air bubbles



Simple
hardscaping for
climate
adaptation



- Transfer tile onto curved mold using plastic sheet
- It takes ~2 weeks for the tile to cure

Stockholm Biochar Streets Project



Stone chips / crushed
granite (2-6mm)
6/8 volume parts
+ nutrient-enriched biochar
1/8 volume parts
+ compost
1/8 volume parts



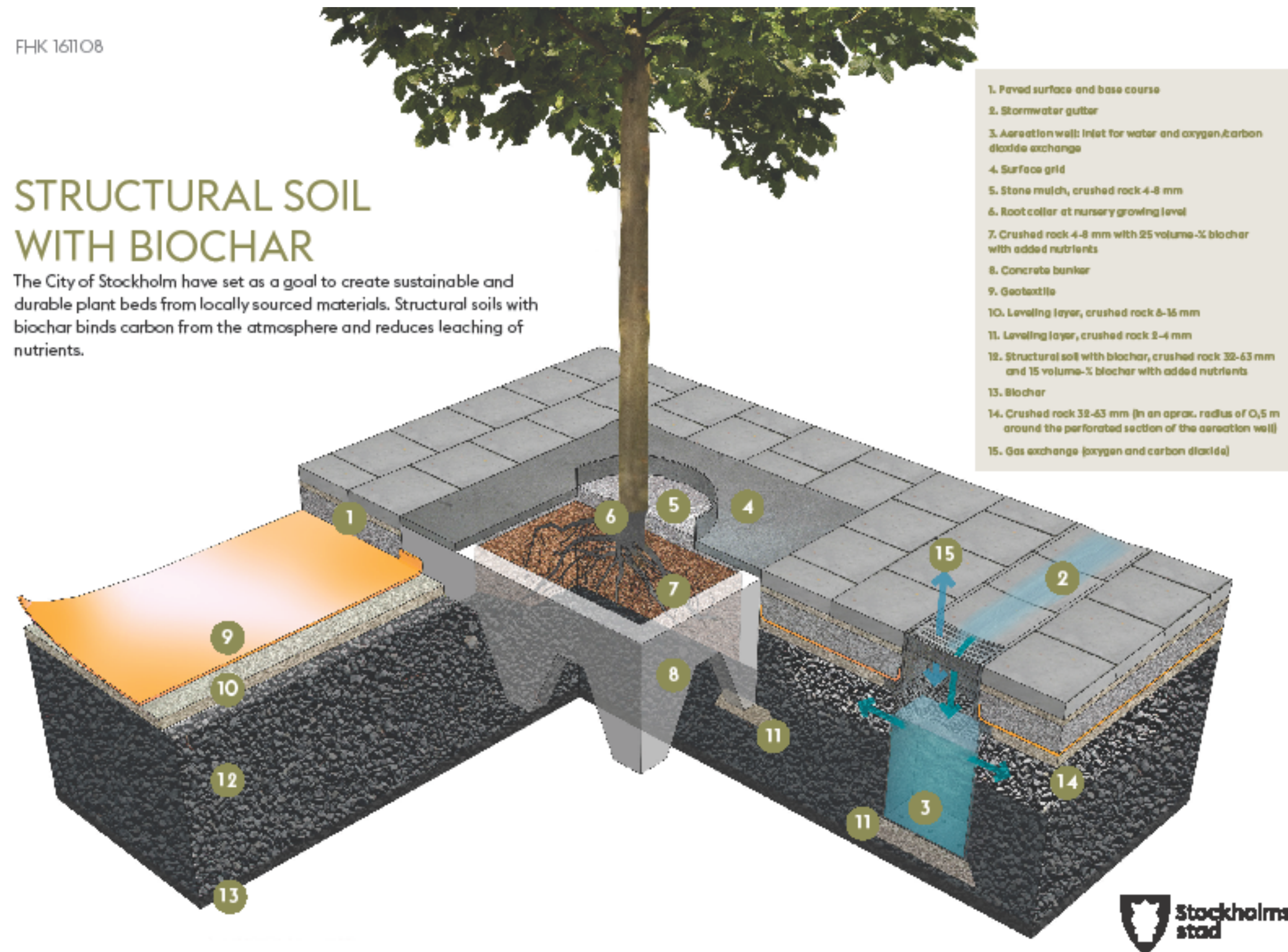
Stockholm Biochar Streets Project



FHK 161108

STRUCTURAL SOIL WITH BIOCHAR

The City of Stockholm have set as a goal to create sustainable and durable plant beds from locally sourced materials. Structural soils with biochar binds carbon from the atmosphere and reduces leaching of nutrients.



Several problems — with a common solution

WITH BIOCHAR:

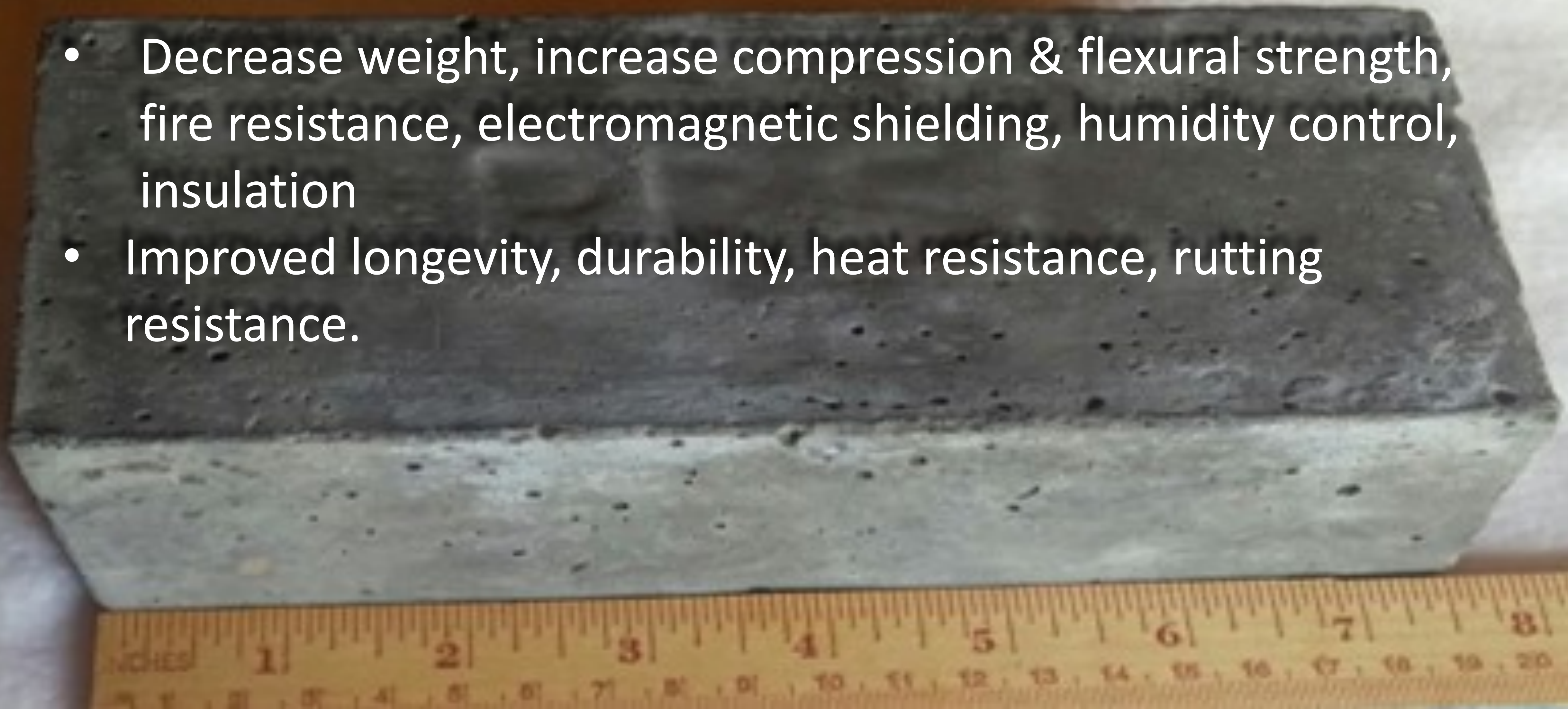
1. Trees stopped dying, grew 10x faster and in difficult locations
2. City reduced the risk of flooding from extreme storm events
3. Cleaned street water effluent before it polluted Baltic, saving nitrogen and potassium
4. Reduced the presence of particles and carbon dioxide in the air
5. Reduced the heat island effect
6. Locked carbon into the ground, meeting the Paris goals

A cascade of solutions from a single strategy

Paints and Plasters



- Decrease weight, increase compression & flexural strength, fire resistance, electromagnetic shielding, humidity control, insulation
- Improved longevity, durability, heat resistance, rutting resistance.





Biochar Biocomposites



Adding a little biochar to
almost anything
helps sequester carbon!



PETE



HDPE



V



LDPE



PP

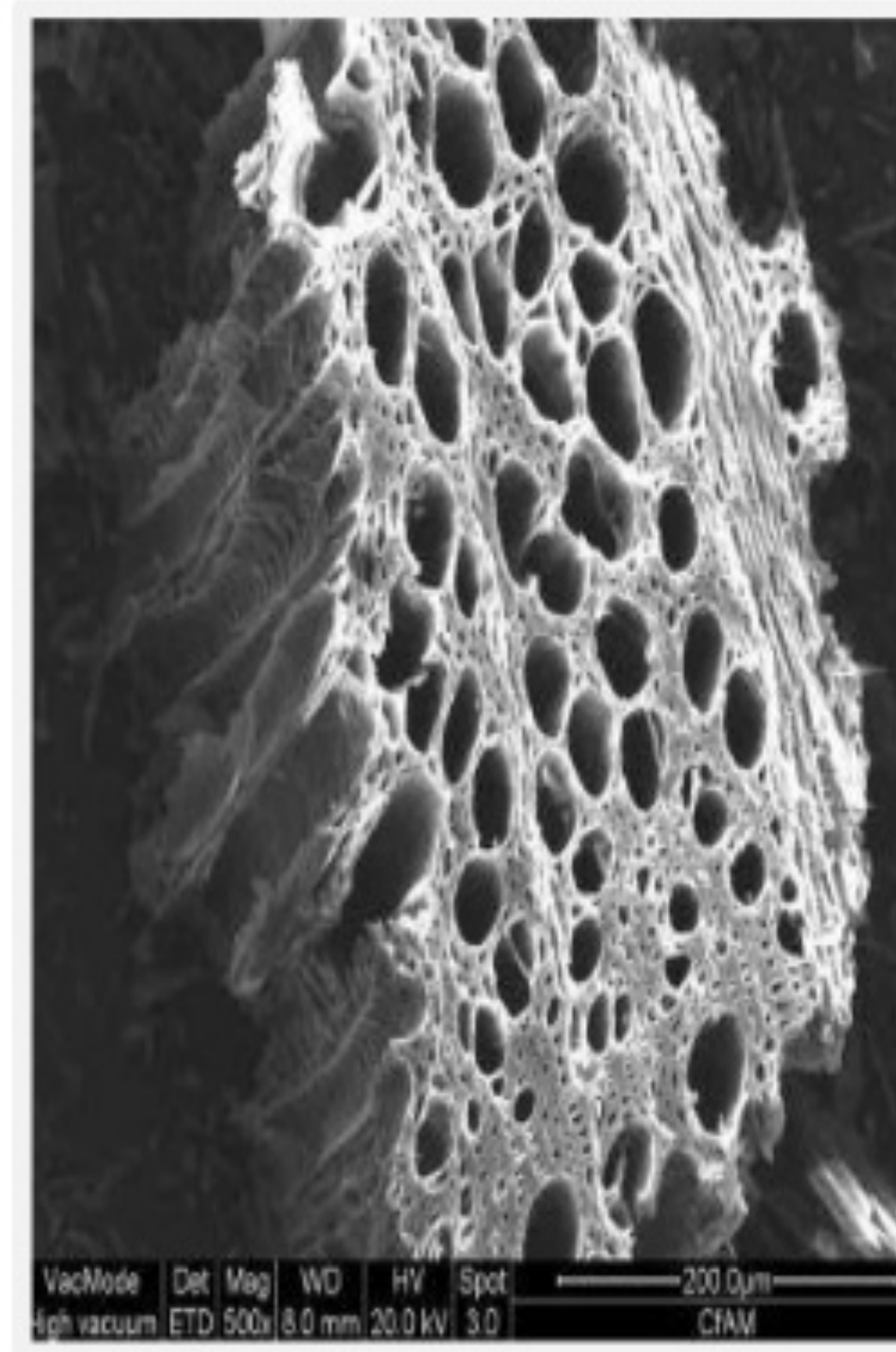


PS



PC

Filtration Nation



Water

- ***Prevention of Contamination***
- ***Decontamination***

Soils

- ***Reclamation***
- ***Immobilization***
- ***Retention***

Removal of E.coli, fecal coliforms, lead, cadmium, arsenic...

Petroleum Flip-Flop: the Displacement Strategy



Carbon Black
Activated Carbon
Think: spider silk!



Tires



Rubber soles



Dry batteries



Inks



Carbon Comfort: Reimagining Everyday Life



Biochar Products Today

What does the product target?

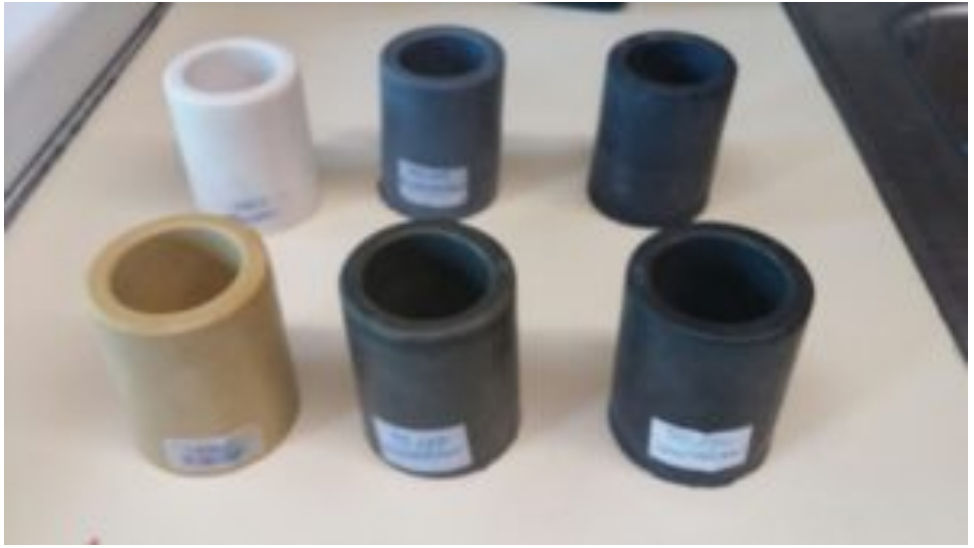


Dr. N. Sai Bhaskar Reddy
e-geo.org | biocharindia.com

What could they be targeting?



Pets, Personal Care, Pillows, Paints & Plasters



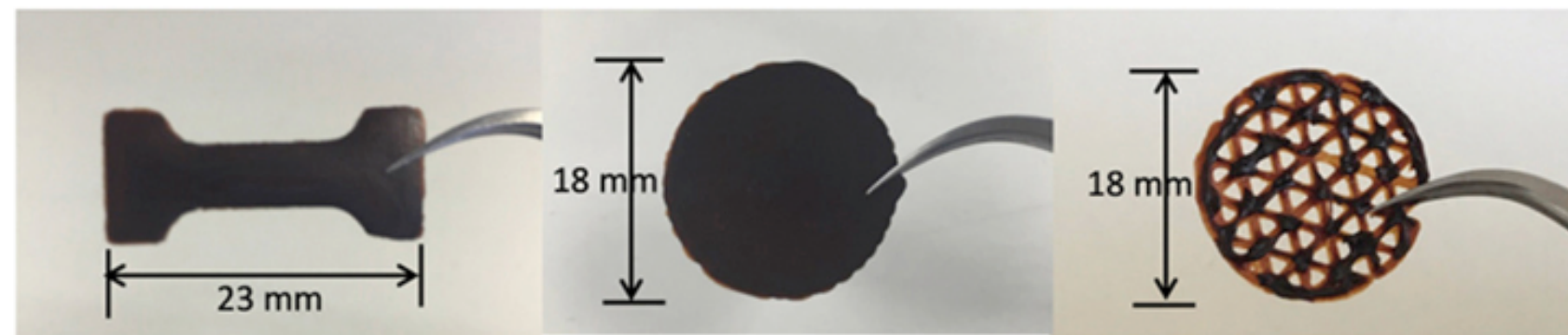
My Tesla Runs on Banana Peels



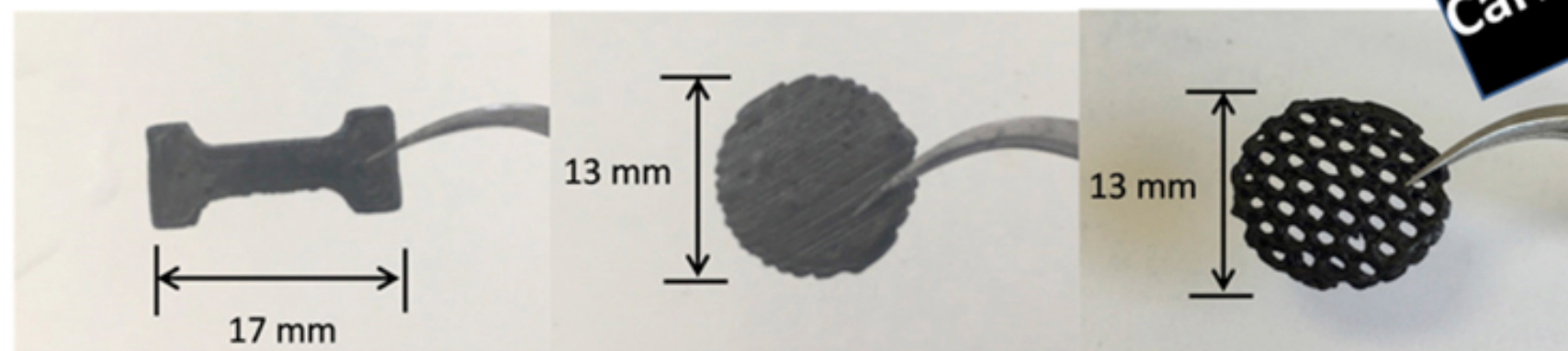
Energy Storage

- SuperCaps
- Lithium sulfur

3D printed precursors from biomass



After carbonization



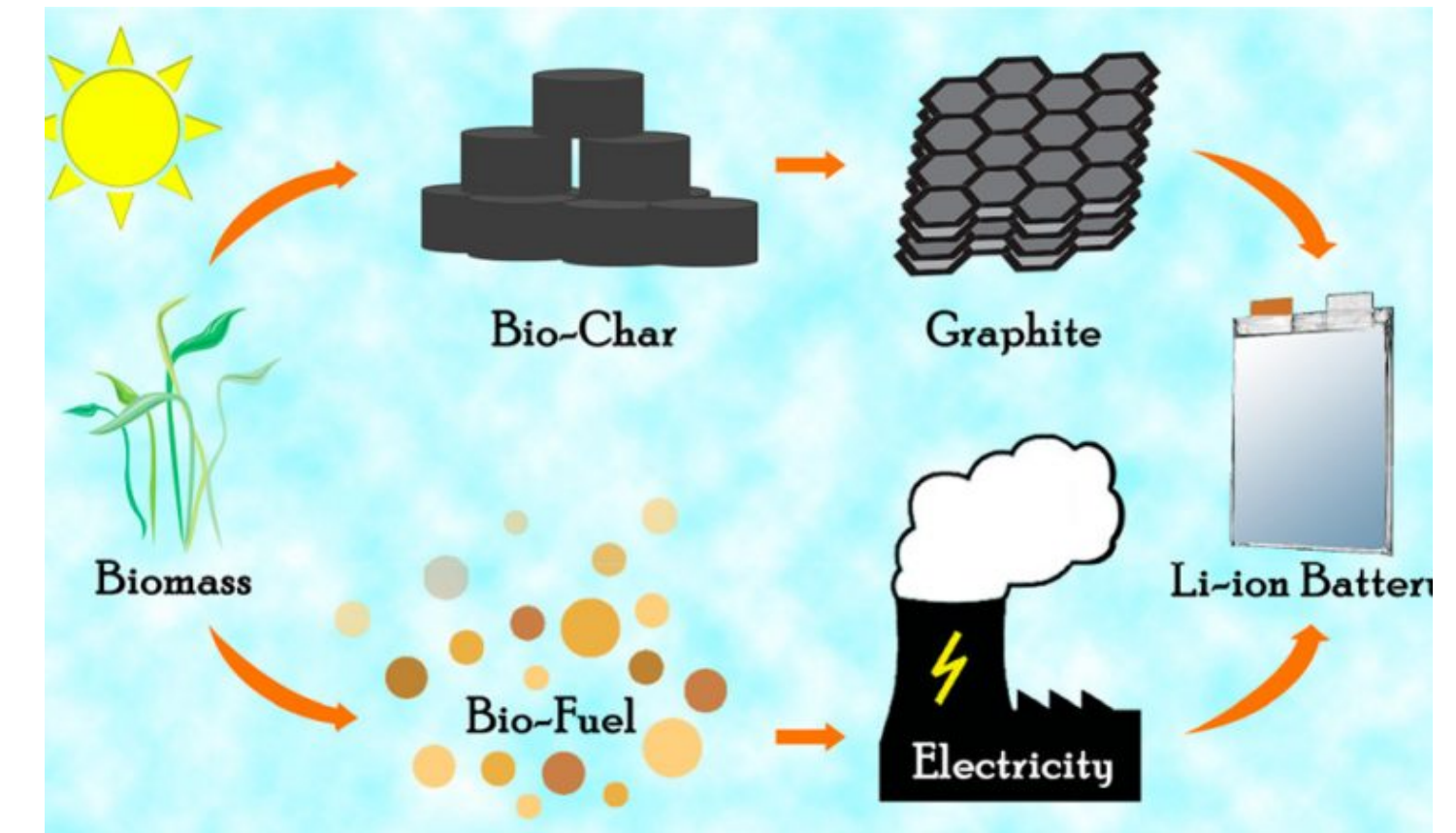
Carbon properties

Low density of 0.74 g/cm^3

Important porosity of 0.58

Electrical conductivity of 47.8 S/cm

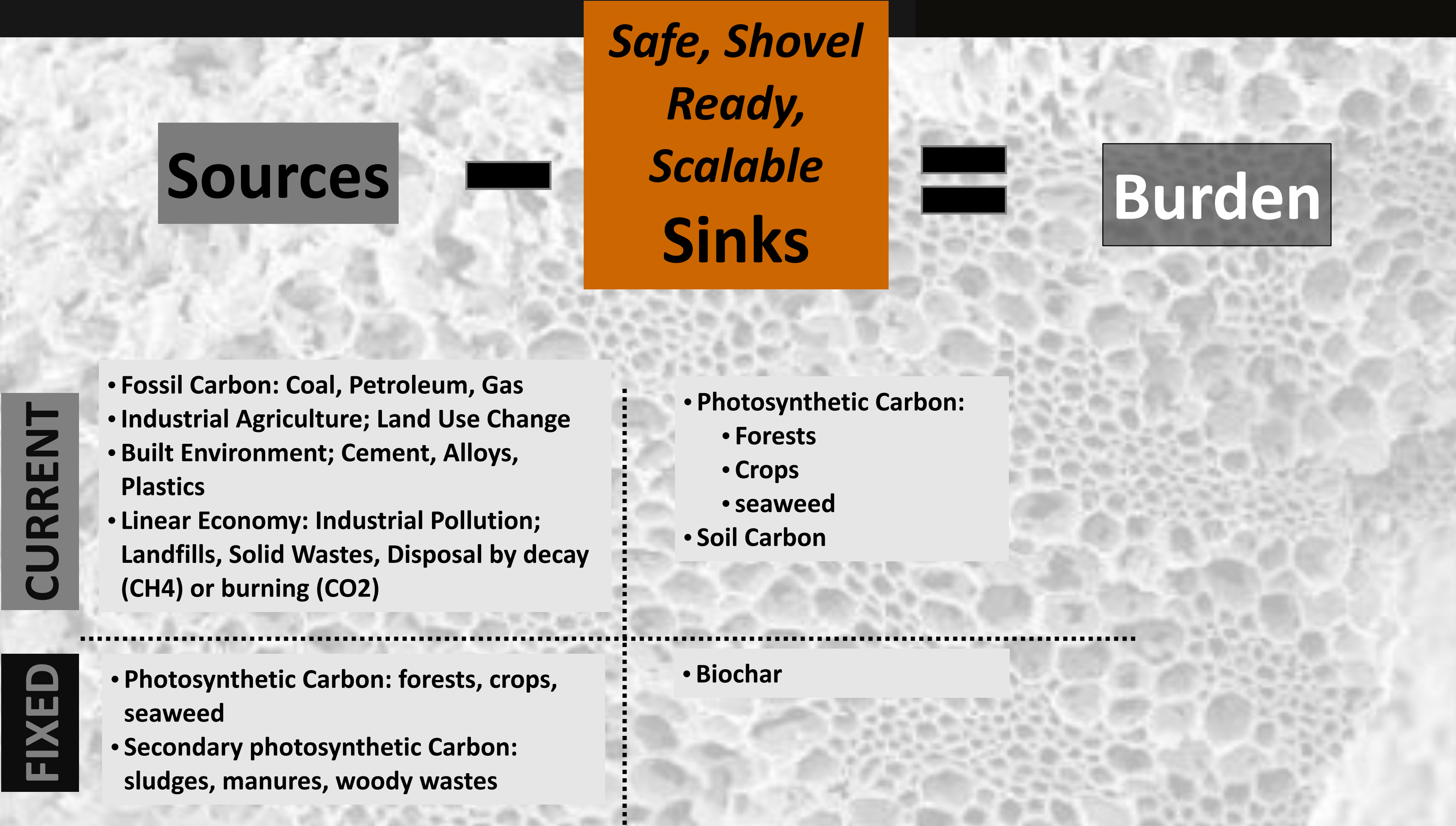
Elastic modulus of 6.62 GPa



<https://chembites.org/2018/11/14/making-new-batteries-using-burnt-plants/>



Carbon Math



China expands fertilizers made from crop waste



2018: 200,000 tons

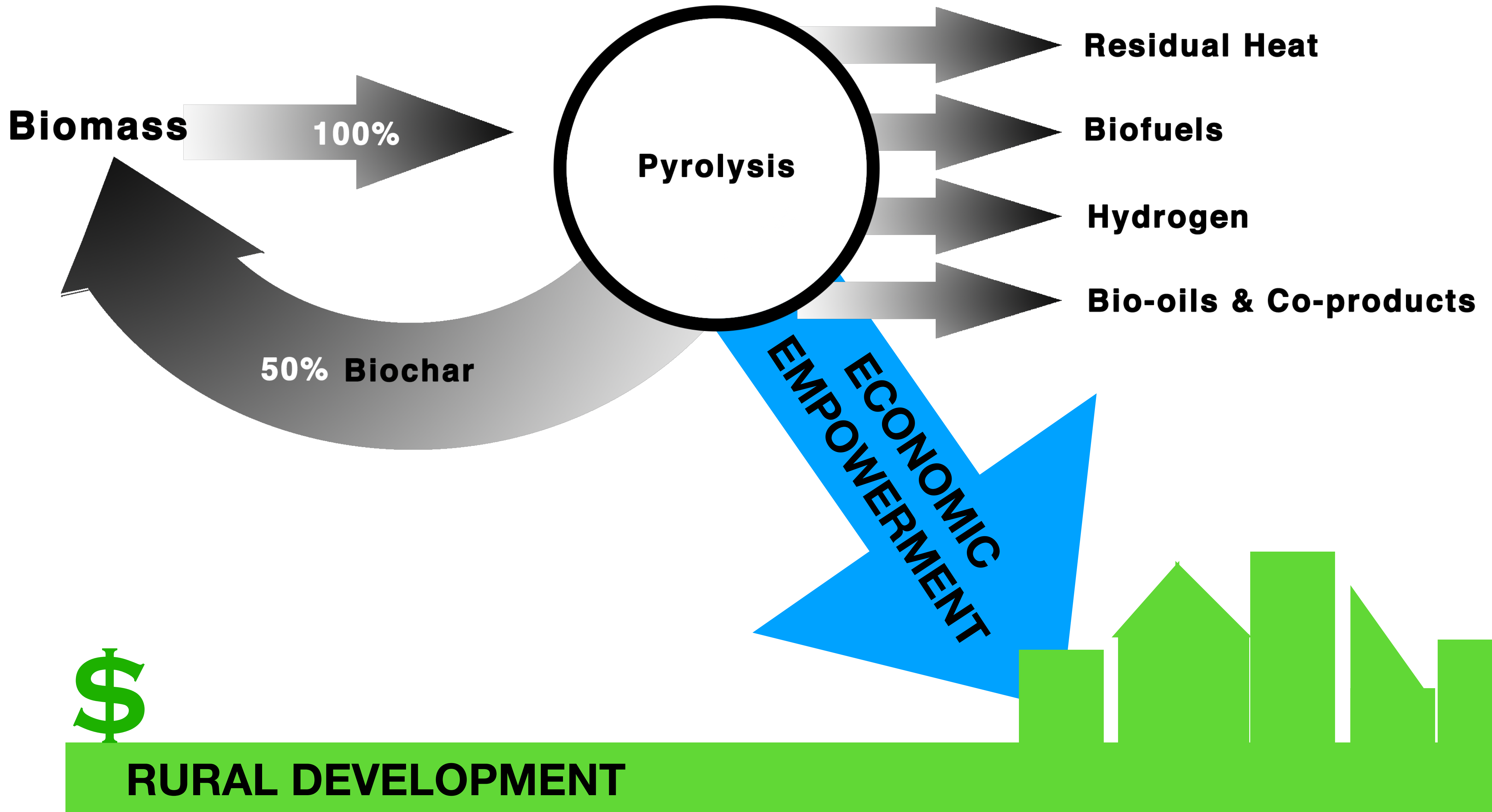


Courtesy T.A. Miles



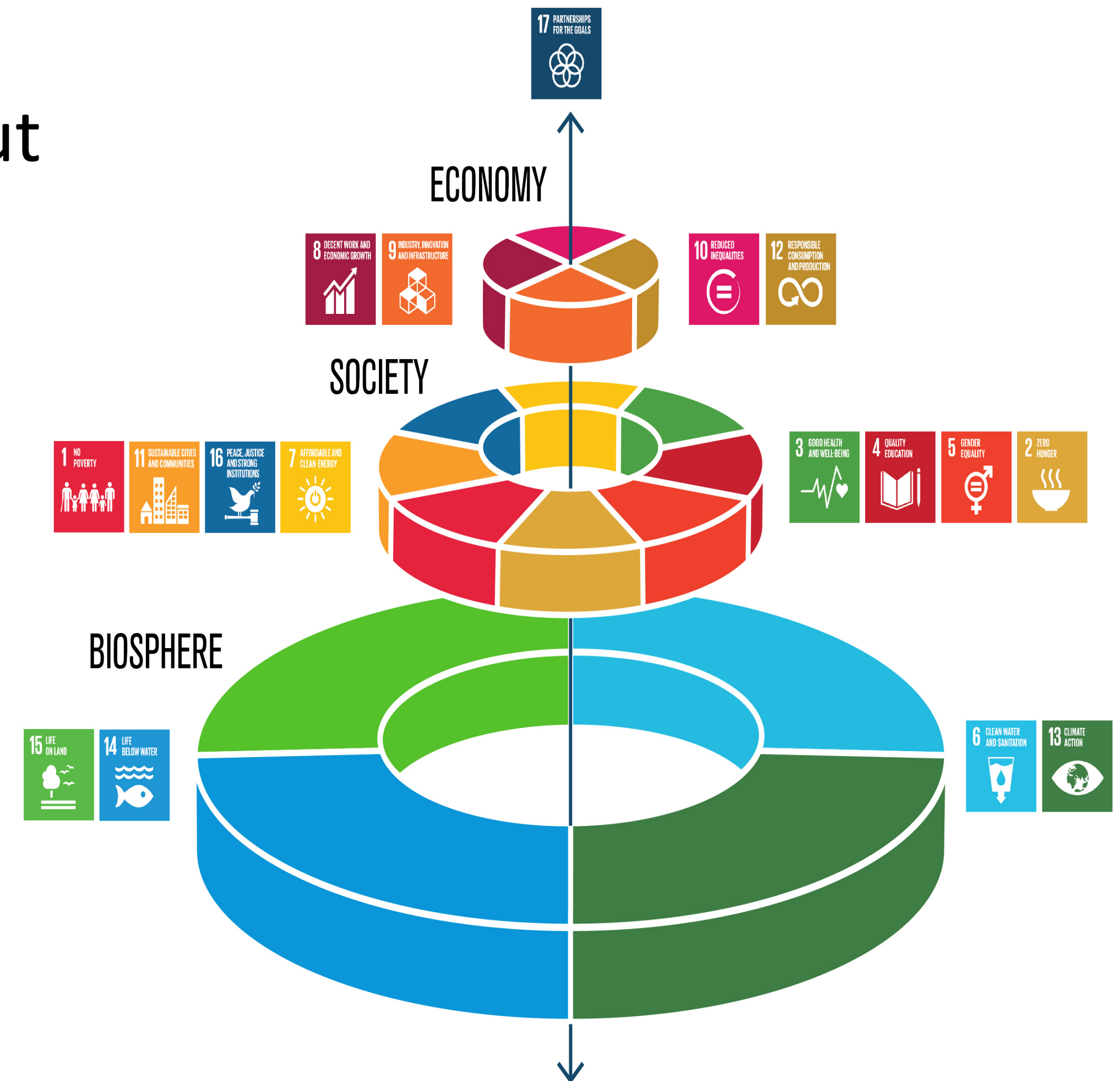
China creates ecovillages near biorefineries





It is technologically possible to redeem the atmosphere to its pre-industrial condition, but only by following these specifications:

- low-cost
- rapidly deployable
- hugely scalable
- capable of quick political and social acceptance
- without the requirement of carbon taxes or offset market subsidies
- antifragile
- have adequate incentives to function in the absence of the petroleum economy
- not endanger ecosystems
- not impoverish individuals, sectors or countries.




Graphics by Jerker Lokrantz



**KEEP
CALM**

**WE ARE
EXPERIENCING**

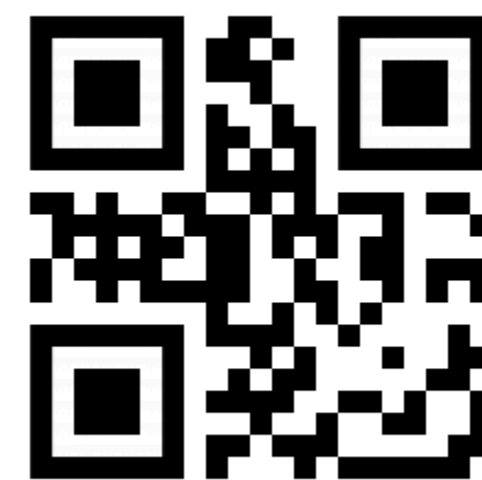
PARADIGM SHIFT

A grayscale microscopic image of plant tissue, showing elongated, rectangular cells with prominent cell walls and internal structures, possibly chloroplasts. The cells are arranged in a somewhat regular, grid-like pattern.

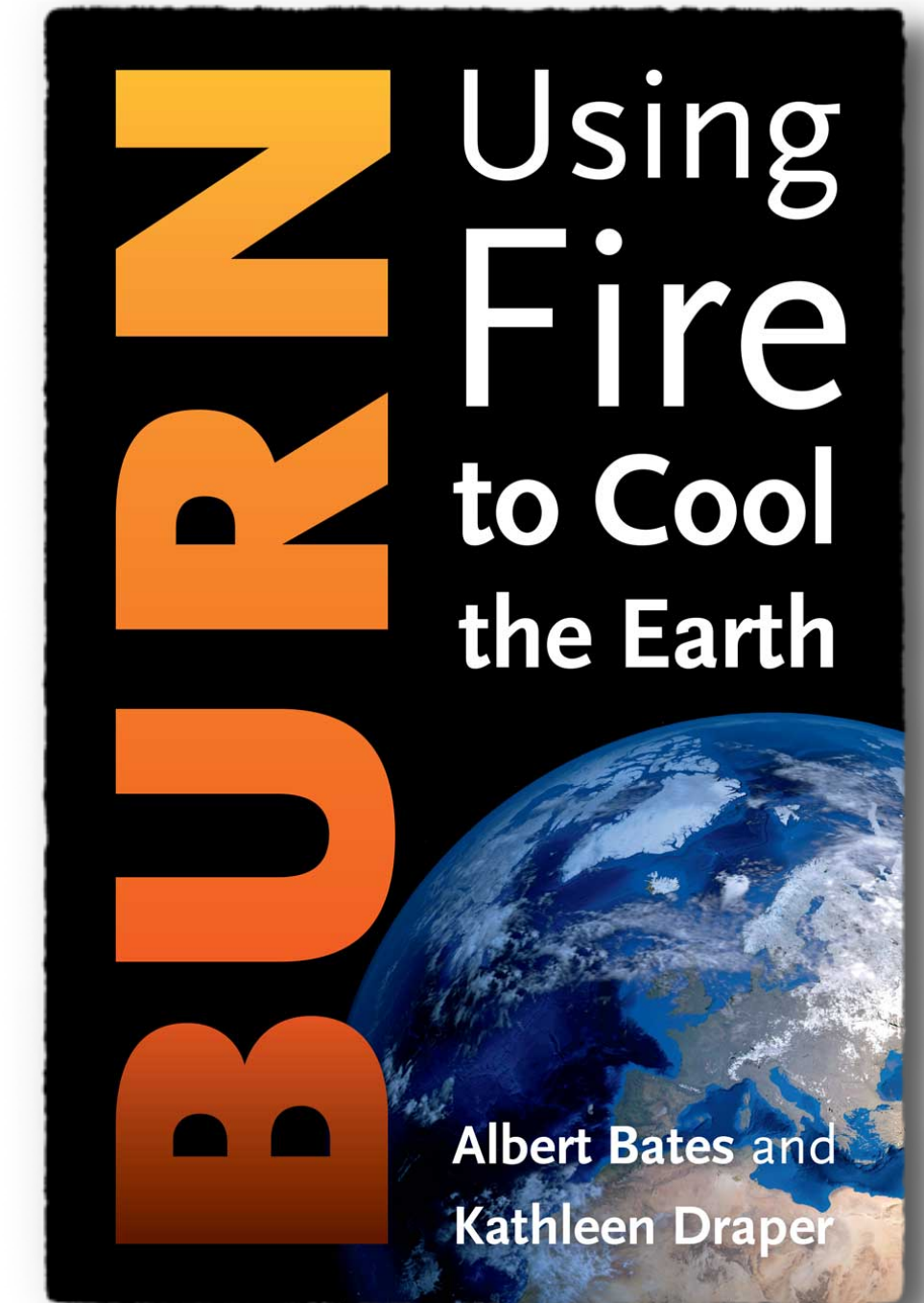
**Time is short.
Options are limited.
Try biochar*:
safe, scalable & shovel
ready**

** One of only 6 negative emissions technologies the IPCC believes can materially help rebalance carbon.*

Please support
our continuing research
and development of these
exciting solutions!



CHARPE DIEM



**Albert Bates
&
Kathleen Draper**

