The New Carbon Economy

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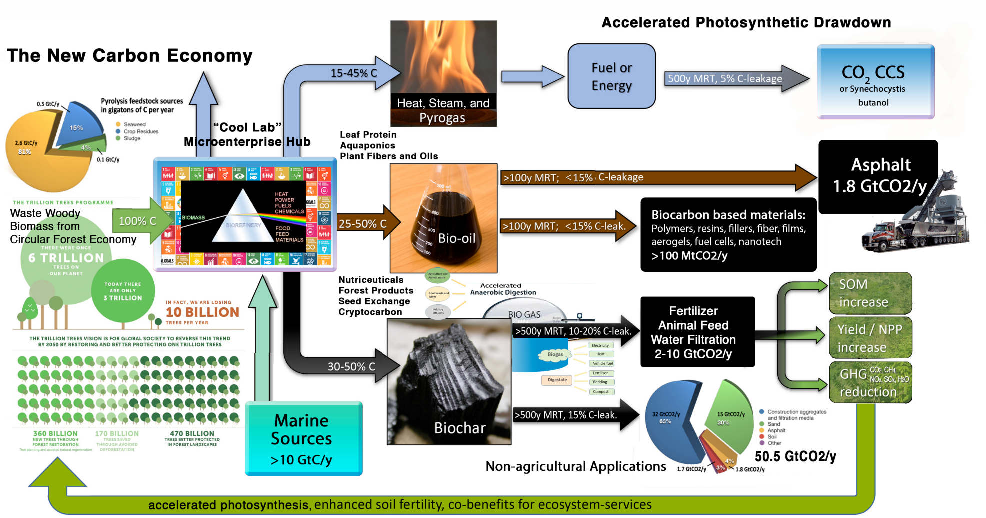
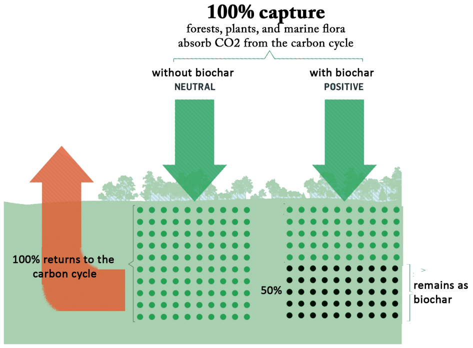
ABSTRACT

In the IPCC's Special Report: Global Warming of 1.5 °C (2018), biochar was listed as one of several promising negative emissions technologies (NET). Others, including bioenergy with carbon capture and storage (BECCS), afforestation and reforestation (AR), direct air carbon capture and storage (DACCS), ocean sequestration, and enhanced weathering, may be technically and geophysically feasible, but their speed, scale, energy, and economic costs pose implementation challenges, even if the issues of public acceptance and absence of economic incentives were to be resolved. The large potential of afforestation and the co-benefits if implemented appropriately (e.g., on biodiversity and soil quality) will diminish over time, as forest carbon saturates. Soil carbon sequestration has co-benefits with agriculture and is cost-effective but likewise has a finite potential. Unlike these, biochar is safe, scalable and shovel-ready, supplies co-benefits that address a majority of the United Nations' Sustainable Development Goals, can self-finance, and is not limited by either feedstocks or sink temporality. We show how farmer livelihoods have been improved; contaminated soils remediated; food made less toxic; wastewater cleansed and reused; cities cooled and freshened; electrosmog blocked; non-point-source pollution in lakes and oceans absorbed; renewable heat or electricity generated; and circular economies engendered by converting waste organic materials into dozens of new climate friendly products—carbon concrete, asphalt, building materials, cosmetics, fabrics, polymers, fuel cells, and 3-D printing filament. We conclude that biochar's drawdown potential has been understated and provide a timeline that more accurately quantifies its non-agricultural potential.



HOW BIOCHAR DRAWDOWN WORKS



With full life-cycle accounting, 50-75% of the carbon returns to the carbon cycle and 25-50% remains for centuries, giving the atmosphere and oceans a time-out. Biomass plantations are not required. Diverting biomass waste products is enough.

Methods and Findings

The Intergovernmental Panel on Climate Change suggests that an increase of 1 billion hectares of forest will be necessary to limit global warming to 1.5°C by 2050. (IPCC 2018) Other studies have put the potential forest area available to return the atmosphere to pre-industrial CO2 concentrations as high as 4.4 billion hectares. (Bastin 2019) However, without sequestering photosynthetic carbon once it begins to decay, any plan to expand Earth's forest cover will be only carbon neutral, not net drawdown.

We examined thousands of published peer-reviewed journal articles that looked at some aspect of reforming carbon from its labile, or continuously-cycling, molecular structure to the recalcitrant, or relatively permanent, form typically labeled "biochar." Biochar is distinguished from charcoal in that its use is for soil improvement or carbon sequestration rather than as a fuel.

When forest or natural grassland is converted to cropland, up to one-half of the soil carbon is lost, primarily because annual tilling increases the rate of decomposition by aerating undecomposed organic matter. About 55 billion tons of carbon (55 PgC) has been lost historically in this way. (Pacala 2004) Carbon farming or climate-smart practices such as conservation tillage, the use of cover crops, and erosion control can reverse such losses, but unless biochar is recovered from normal crop wastes, these practices will be, eventually, only carbon neutral.

How much carbon dioxide can biochar withdraw annually? From our review, we estimate the drawdown potential from agriculture with pyrogenic capture and storage to fall within the range of 1.7 to 10 PgCO2-e a-1 (petagrams or billion metric tonnes carbon dioxide equivalents per annum). (Woolf 2010) Anthropogenic emissions are currently 37-39 PgCO2-e a-1 and rising. Even optimistically assuming a 50-percent reduction in industrial emissions by 2050, much more than 10 Pg annual withdrawal will be required.

Fortunately, our review indicates that humanity already possesses the fundamental scientific, technical, and industrial know-how to rebalance Earth's climate within the next half-century. In addition to crop and forestry wastes, available carbonaceous feedstocks that can be rendered into biochar include municipal landfill wastes, sewage sludge, seaweed, and numerous industrial waste streams. Applications for biochar extend far beyond farm and forest to include asphalt surfaces for highways, concrete for buildings and bridges, carbon fiber for vehicles and appliances, cathodes for batteries and fuel cells, ingredients for foods, feeds, and cosmetics, additives for polymers, and much more. We have estimated the drawdown potential from these feedstocks and storages will fall within the range of 48 to 60 PgCO2-e a-1. (Bates and Draper 2019).

If we assume a gradual 7-percent decline in anthropogenic emissions over the coming decades, in line with the Paris Agreement, coupled with a gradual deployment of pyrogenic carbon capture and storage that takes advantage of these novel feedstocks and applications, we can project a timeline by which atmospheric concentrations return to 350 ppmv CO2 in the second half of this century and the century closes with atmospheric concentrations at approximately 300 ppmv.

Conclusion

A portfolio of technologies now exists to meet human energy and materials needs over the next 50 years while withdrawing enough atmospheric (and oceanic) CO2 to recover preindustrial concentrations. Every element in this portfolio has passed beyond the laboratory bench and demonstration project; many are already implemented somewhere at full industrial scale. The single greatest drawdown wedge is conversion of waste biomass to biochar and displacement of non-carbonaceous products with carbon of photosynthetic origin.

References

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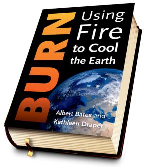
About the Authors

Kathleen Draper is US Director of the Ithaka Institute for Carbon Intelligence, an open source network focusing on beneficial carbon sequestration strategies that simultaneously provide economic development opportunities both in the developed and developing world.

Albert Bates is a lawyer, scientist, teacher and founder of the Global Village Institute. His books include *The Biochar Solution; Burn: Using Fire to Cool the Earth; Climate in Crisis; The Post-Petroleum Survival Guide and Cookbook; Transforming Plastic: From Pollution to Evolution* and *The Paris Agreement.*



TIMELINE

Timeline of projected results at Mauna Loa Observatory from drawdown of legacy CO2, assuming ocean feedback and emissions neutrality by 2050

YEAR	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080	2085	2090	2095	2100
PPMV	450	447	444	440	435	430	424	418	412	404	396	386	376	362	350	338	320	300