Biochar Primer – Unlocking the Potential of Carbon

Introduction

This document introduces the transformative potential of biochar—an innovative, versatile material created through the thermal conversion of organic biomass. Biochar is a stable, carbon-rich material produced by heating organic biomass—such as wood chips or crop residue—in the absence of oxygen. Biochar looks like charcoal but is engineered to enhance soil, sequester carbon, and serve as a versatile input for agriculture, construction, and industrial applications.

Although biochar is gaining attention as a modern climate and agricultural solution, it is anything but new. In fact, its origins trace back over 2,000 years to the Amazon Basin, where Indigenous peoples enriched poor rainforest soils with what we now call "Terra Preta" or "dark earth." These fertile zones were created by incorporating charcoal, food scraps, and organic waste into the soil—effectively an early form of biochar production. Modern science is rediscovering and refining this ancient practice using advanced technology to deliver consistent, high-quality biochar at scale. This blend of ancient wisdom and modern engineering is what makes biochar so compelling today.

Biochar is drawing interest across agriculture, energy, environmental remediation, construction, and materials science. This primer is designed to help business professionals understand how and why biochar is entering mainstream sustainability and decarbonization strategies.

1. Why Carbon Sequestration Matters

Carbon sequestration refers to capturing and storing atmospheric carbon dioxide (CO_2). Human activity releases over 36 billion tons of CO_2 annually, driving climate change and destabilizing ecosystems. Biochar helps lock away carbon from organic waste—like forestry residue or agricultural biomass—in a stable form that can remain in soil or other media for hundreds to thousands of years. Unlike the REDUCTION of new carbon dioxide provided by renewable energies like Solar or Windpower, the biochar process actually removes EXISTING CO_2 from the environment and locks it away. This process directly contributes to climate mitigation efforts and can be monetized via carbon credits.

2. How Biochar is Made

Modern biochar is commonly produced using rotary kiln pyrolysis systems, where biomass is slowly rotated and heated in a long, sealed cylinder with little to no oxygen. This process thermochemically transforms the organic matter into char while separating off valuable co-products like syngas and wood vinegar. The rotary motion ensures even heat distribution and consistent output quality.

Importantly, the thermal energy generated by pyrolysis can be harnessed. Many systems are equipped to recover this waste heat and convert it into usable power or process heat—for example, using an Organic Rankine Cycle (ORC) turbine to generate electricity. This not only boosts energy efficiency but allows for co-location with energy-intensive operations such as drying, greenhouse heating, or even data centers.

While pyrolysis involves heating biomass, it differs significantly from open burning or incineration, which contributes to air pollution. The process takes place in a low-oxygen environment, which prevents full combustion and limits the formation of harmful pollutants. Advanced pyrolysis units are equipped with emission control systems that capture or burn off volatile gases, resulting in extremely low particulate and greenhouse gas emissions. In fact, the process is carbon negative, meaning it removes more carbon from the atmosphere than it emits. This makes pyrolysis a powerful tool for sustainable waste management and climate mitigation.

One of the strengths of pyrolysis technology is its **flexibility in feedstock sourcing**. Biochar can be made from a wide range of biomass inputs—including **forestry slash, utility line trimmings, agricultural residues, purpose-grown energy crops like Paulownia, and even clean wood waste from construction or landscaping**. This diversity allows biochar producers to tailor operations to local material availability and cost.

Agricultural byproducts such as sugarcane bagasse, corn stalks, wheat straw, and rice husks are also excellent candidates for biochar production. These residues are often burned in open fields or left to decompose, releasing CO_2 and methane. By redirecting them into a pyrolysis system, they become valuable inputs for **carbon sequestration and soil enhancement**. Because they're widely available and renewable, agricultural residues are increasingly central to biochar projects in farming regions worldwide.

However, **feedstock consistency is critical** to ensuring high-quality and predictable biochar output. Variability in moisture content, particle size, and composition can affect process stability, emissions, and final product properties such as porosity and nutrient content. To address this, leading biochar operations employ **intake screening, drying**

systems, and preprocessing to standardize input streams and maintain product quality across batches.

3. Key Uses of Biochar

A. Soil Remediation and Agriculture

- Improves soil fertility and moisture retention.
- Buffers pH and reduces fertilizer runoff.
- Enhances crop yields and microbial activity.
- Ideal for regenerative farming, degraded lands, and organic applications.

In addition to improving soil structure and water retention, **biochar serves as an ideal carrier for microbial and nutrient additives**. Its porous structure provides a protective habitat for beneficial bacteria and fungi, helping them colonize the soil more effectively. A common practice is to **"charge" the biochar by blending it with organic nutrients** like **compost, manures (e.g., chicken litter), or liquid microbial inoculants** before application. This transforms biochar from a passive soil conditioner into an **active biological delivery system**, accelerating improvements in crop yield, root health, and overall soil regeneration.

B. Cement, Asphalt, and Carbon Steel Additives

- Biochar can be added to concrete and asphalt to improve durability and reduce the carbon footprint.
- In metallurgical processes, it can partially replace coke in carbon steel production.
- These industrial markets are expanding rapidly under green construction initiatives.

Biochar is gaining traction in **industrial material applications**—notably in cement, asphalt, and carbon steel manufacturing—due to its strength-enhancing properties and carbon sequestration potential.

In the **concrete and cement industries**, biochar can serve as a **partial substitute for cement or filler materials**, reducing overall emissions from cement production. Cement is one of the most carbon-intensive materials on Earth, responsible for ~8% of global CO_2 emissions. By blending in biochar—typically at rates of **5–10% by volume**—manufacturers can **lower embodied carbon**, increase durability, and improve water resistance. Some studies even show enhanced compressive strength, depending on the type and size of the biochar particles used.

In **asphalt**, biochar functions as a performance enhancer and stabilizer, improving viscosity and extending pavement life. Its hydrophobic nature helps it resist water damage and rutting, making it a promising additive in road construction.

For **carbon steel applications**, biochar can be used as a **renewable reductant in metallurgical processes**, replacing traditional coal-based coke during smelting. This offers the dual benefits of **reducing fossil carbon inputs** and **earning carbon offset credits**, while maintaining the heat and chemical properties needed for steelmaking. Several pilot projects globally are exploring this use to decarbonize steel supply chains.

C. Graphene and Advanced Materials

- Biochar serves as a precursor for graphene through ultrasonic exfoliation techniques.
- Graphene is used in electronics, energy storage, and nanomaterials.
- Yield from biochar can reach 30–32%, creating high-value outputs from carbon-rich feedstocks.

One of the most exciting frontiers for biochar is its role as a **precursor for graphene**, a revolutionary material known for its exceptional strength, electrical conductivity, and thermal performance. Through processes such as **ultrasonic or electrochemical exfoliation**, biochar's carbon matrix can be broken down and restructured into **few-layer or even monolayer graphene flakes**. This opens the door to using renewable biomass—not fossil fuels—as a feedstock for high-performance materials.

Graphene derived from biochar is being explored in **battery technology, supercapacitors, water filtration membranes, composite materials, and electronics**. Companies such as MEP of Miami are already working on scalable, on-site processing systems to convert biochar directly into graphene using ultrasonic cavitation techniques.

While yields are still evolving with process improvements, estimates suggest that **1 ton of high-quality biochar can yield 50–100 kg of usable graphene**, depending on purity and source material. As production methods mature, biochar-derived graphene could provide a **low-cost, sustainable path** to a material once considered prohibitively expensive and energy-intensive to produce.

D. Animal Feed and Digestive Health

- Biochar is approved in some regions as a livestock feed additive.
- It helps improve digestion, reduce methane emissions, and bind toxins in the gut.
- Also used in bedding for odor control and pathogen reduction.

Biochar is increasingly being used as a **feed supplement in animal agriculture**, particularly in Europe and parts of Asia, with growing adoption in North America. When added in small amounts (typically 0.5% to 2% of dry matter), **biochar can improve digestion, reduce methane emissions from ruminants, and enhance nutrient uptake**. It binds toxins and heavy metals in the digestive tract, reducing stress on the animal's system and lowering disease incidence.

Studies have shown positive effects in **cattle, poultry, pigs, and even fish**. In poultry, for instance, biochar in feed can reduce ammonia in manure, leading to healthier birds and less environmental impact. After digestion, the **biochar-rich manure becomes a highly valuable soil amendment**, effectively closing the loop between livestock management and regenerative agriculture.

E. Algae Bloom Control and Water Treatment

- Biochar filters and captures nutrients (like phosphorus and nitrogen) that cause algae blooms.
- Deployed in wetlands and retention ponds to restore water quality.
- Also used in stormwater filtration and wastewater treatment systems.

Biochar can be used in water bodies—such as ponds, lagoons, and swampy wetlands—to **help reduce algae blooms and improve water quality**. Its high surface area and cation exchange capacity allow it to adsorb nutrients like **phosphorus and nitrogen**, which are often the root cause of eutrophication and algae proliferation.

Biochar can be deployed in **floating filter socks**, **permeable mesh bags**, or **fixed beds** placed in water inflow zones. These structures passively filter nutrients and reduce turbidity as water flows through or around them. In field trials, applying **1–2 kg of biochar per square meter of surface water area** has shown measurable improvements in clarity and algae reduction over several weeks.

Additionally, placing biochar at key runoff entry points or integrating it into **constructed wetlands** can intercept nutrient flows before they enter sensitive aquatic ecosystems. This makes biochar an attractive solution for farms, golf courses, or municipalities dealing with pond algae or nutrient runoff challenges.

4. A Scalable, Sustainable Business Model

Biochar offers commercial viability, environmental impact, and multiple product revenue streams. Whether used to improve soil, capture carbon, support livestock health, or feed the future of materials science, biochar represents a rare convergence of profit and sustainability. New World Carbon, in partnership with AED, is building the infrastructure to deploy, manufacture, and sell high-grade biochar through a national network of partners.