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Sustainable carbon sources for industrial applications

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Within the next few decades, greenhouse gas emissions will need to be reduced whilst biodiversity is conserved. In order to attain these goals, many industrial processes will need to be performed in novel ways.

Sustainable sources of carbon are required for many materials, including plastics, ceramics, jet fuel, lubricants etc. Green steel making, whereby biomass is substituted for coking coal, has garnered much attention.

However, sources for the carbon require investigation for both quantity and sustainability.

The increased production and consumption of biomass is often touted as a solution for carbon supply for green steel and other applications. Biomass is currently being used in significant quantities for home fuel (firewood), electricity generation and as a supplement in liquid fuel for road transport. Some of this biomass is waste (such as bagasse and methane from rubbish tips) and some is purpose-grown (such as trees for firewood and ethanol for motor fuel).

The use of waste biomass for energy is generally desirable if carefully managed (it must be noted that this resource is often remotely located, requiring transport over long distances, which can add to cost and detract from carbon neutral status). In contrast, the widespread use of purpose-grown biomass energy has the potential to cause large environmental damage, possibly worse than continued use of fossil fuels. Biomass competes with ecosystems, food production and timber production for land, water, pesticides and fertilisers. New cropland and grazing land is often gained at the expense of old growth forests and grasslands, which destroys valuable habitat for endemic flora and fauna, and reduces carbon sinks. Unfortunately, the energy conversion efficiency (sunlight to chemical energy or electricity) of biomass is very low, typically 0.1-1%. This is a small fraction of the conversion efficiency of solar PV and hence much more land is required – and this has to be arable land.

Trial biomass programs typically overestimate the growth potential of crops, due to several factors, including edge effects (smaller plots have a greater percentage of plants on the edge of the planting and therefore receiving more direct sunlight, which improves growth), and the dedicated attention of researchers. Breeding and development of new annual and perennial species is a slow process.

Finally, regenerative farming methods are sorely required in order to sequester carbon. Balancing this sequestration while intensifying agriculture for energy and industry is a fraught process.

We investigate the availability, sustainability, feasibility and possible costs of sustainable sources of carbon, including waste biomass, cropped-biomass and direct air capture of carbon dioxide.