Dear Friends,

Last month I had written:

‘Bending the curve implies drastic reduction in human CO₂ emissions, while at the same time engineering carbon sinks (yellow) and reverse the GHG emissions from land use and land use change. I shall explain this in the next blog’.

This month I shall attempt to discuss in simple terms what is the meaning of ‘engineering carbon sinks’. We shall deal with reversing the GHG emissions from land use and land use change in the next month. In order to link these ideas with our own context, I have attempted to link this with the issue of stubbles burning and offered a solution.

**Engineering Carbon Sinks**

By now we are all aware that since the beginning of the industrial revolution, humanity has been emitting CO₂ by burning fossil fuels for our developmental activities, and there has been a large accumulation of this and other greenhouse gases leading to global warming and climate change. Engineering carbon sinks means developing and installing man-made systems that would draw CO₂ from atmosphere or capture them from large scale emissions resulting from burning fossil fuels or cement, steel production (also known as ‘Carbon Capture’) and store them (‘Carbon Sequestration’) using different methods – together known as CCS – Carbon Capture and Storage.

Bio-energy with Carbon Capture and Storage (BECCS) [1] is a process that draws CO₂ from atmosphere while growing any form of biomass. This biomass is converted into charcoal (also known as Bio-char), using modern versions of charcoal making, called ‘Pyrolysis’. Pyrolysis essentially involves heating the biomass in absence of sufficient oxygen, so that the combustion is incomplete. The process is similar to making coke from coal on coke ovens widely used in steel making. Well-developed pyrolysis systems can produce solid, liquid and gaseous fuels.

Carbon removal or carbon dioxide removal (CDR) is different from carbon capture. Carbon capture [2] is a short-term phenomenon, which eventually returns the carbon to atmosphere,
as soon as the captured carbon is burnt again to get energy. Carbon removal means capturing and storing the carbon for long term, 1000 years or more. Carbon Removal is defined as [2]:

“Carbon removal, also known as carbon dioxide removal (CDR) or carbon drawdown is the process of capturing carbon dioxide (CO$_2$) from the atmosphere and locking it away for decades or centuries in plants, soils, oceans, rocks, saline aquifers, depleted oil wells, or long-lived products like cement. Scientists have proposed many different methods of carbon removal. Some of these are already in use at relatively small scales, whereas others remain in the early stages of research and development. Technologies and practices for implementing carbon removal are often called negative emissions technologies (NETs)”.

The following figure explains the difference between Carbon Removal, Carbon Capture and Storage and Carbon Capture and Use.

If the carbon comes from fossil fuels, it is Carbon Capture. If it comes from atmosphere it is Carbon Removal.

If this carbon is used again in the short term, like synthetic fuel, food or beverages, it goes back into the atmosphere and does not help reduce the GHGs. This is called Carbon Capture and Use (CCU).
If the Captured Carbon is put into long term storage like saline aquifers or depleted oil wells, it is called CCS. The carbon is simply recycled back into the earth. But it does not reduce atmospheric CO₂.

Only when the carbon is removed from atmosphere and is put into long term storage like geological formations, the deep ocean, minerals, bio-char, trees and soils and long-lived products like cement, can we call it as Carbon Removal. Only this helps in reducing atmospheric CO₂. This is the principle behind creating man-made carbon sink.

**Stubble burning**

The following Fig. 1 [3] shows a photograph of a large farm, burning stubble left behind after harvesting a crop, in order to prepare the ground for the next crop quickly. Farmers cultivate short-duration rice crops for 4 months during June/July to October / November followed by wheat crops in the next 5 months. As very little time is left in between, they resort to burning the stubble. Annually, about 20 MT of stubble is produced in Punjab alone, and about 80% of it is burnt on the field [3].

![Fig. 1 Picture shows stubble burning.](https://www.agrifarming.in/stubble-burning-reasons-disadvantages-solution)

**Pyrolysis**

As indicated earlier, Pyrolysis means heating biomass in absence of oxygen. This results in the breakdown of the chemical composition of the biomass leaving behind liquid, solid and gaseous fuel residue roughly in the following proportions, according to U.S. DEPARTMENT OF AGRICULTURE - Agricultural Research Service (USDA – ARS) [4]:

Optimum Output  
Bio-oil: 60-70%; Bio-char: 15 – 20%; Syngas: 10-15%
The optimum conditions are a heating temperature of around 500°C and a heating rate of 1000 °C/sec. The process can sustain itself in energy terms, as part of the fuel may be used to provide the required energy.

![Schematic of the Fast Pyrolysis Process](image)

The USDA – ARS notes:

“(We) envision a distributed processing model where many small scale pyrolyzers (i.e. farm scale) covert biomass to bio-oil which is then transported to a centralilized location for refining. Our studies show that when employed in a distributed "farm scale" systems feeding into a central gasification (for Fisher Tropsh liquids production) plant the transportation cost savings alone are enough to offset the higher operational and biomass costs”.

Let us hope that we are able to develop effective pyrolizers for addressing the stubble burning problem and derive some fuel from the stubble. Please refer the links below for more information on the subject.

I would love to hear your comments. Please send them to s_banerji@amrita.edu.