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FACTSHEET: BIOENERGY WITH CARBON CAPTURE AND STORAGE

BECCS: REACHING GLOBAL GOALS OF ENERGY SECURITY AND CLIMATE CHANGE ABATEMENT

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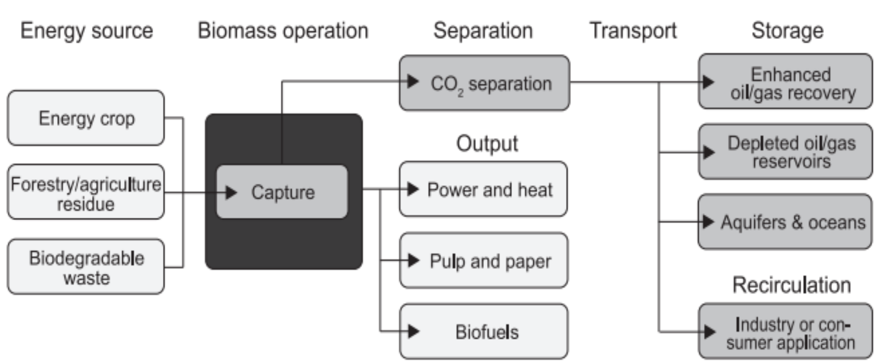
Bioenergy with carbon capture and storage or **BECCS**, is the production of bioenergy using biomass, coupled with the harvesting and subsequent storing of carbon dioxide. This storing of carbon dioxide can be underground, in oceans, or in forests.

BECCS Process: The concept behind these technologies have been employed by the oil industry to enhance oil recovery by injecting the co_2 into the oil field. But new designs are being developed to facilitate the processing of biomass residue in the agriculture, forestry, and industrial sectors. The BECCS technology is a three-step process:

1. **Cultivating feedstock**
2. **Burning biomass feedstock to generate electricity**
3. **Capturing and storing the carbon emitted**

The figure below depicts the general process of BECCS; outputs of BECCS include power and heat, pulp and paper, and biofuels. The capture and storage can be done pre-combustion, during the combustion (oxy-fuel), and post combustion.



Currently there is an underutilization of biomass as an energy source because of cost considerations, but with new designs, and when carbon capture is assigned economic value, the production of energy from biomass is likely to increase and a significant level of carbon sequestration can emerge.

WHAT ROLE DOES BECCS PLAY?

BECCS provides an alternative source of energy, while utilizing carbon negative technologies.

One can plant dedicated trees and biomass feedstock that is then harvested and used in energy generation, with the carbon emitted captured and stored or recycled; this also contributes to rural development.

Alternatively, one can use forestry and agricultural residue as the source of biomass for energy.

Using forestry residue will not only result in energy generated with carbon negative technologies, but also create value added uses for forest residue and yard debris – two feedstocks that are associated with wild forest fires.

Using biomass to generate heat and power is not new, but is currently gaining interest because of recent developments in the carbon capture and storing technologies, and demand for clean technologies

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EFFECTS ON THE OCEAN

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- While oceans can store CO_2, they can only do this to a certain extent. This limitation is present because of the maximum levels of CO_2 that can chemically be mixed with ocean water contents without devastating ocean chemistry and its creatures.
- Injecting CO_2 in the deep sea in large volumes may alter ocean chemistry, increase acidity, and result in harm to sea creatures.[7]
- Alternatives to ocean intake of CO_2 that can mitigate these effects include utilizing other storage sites, which can be done through geologic carbon sequestration.
- Another promising alternative is utilizing CO_2 in the production of other products such as cement and maybe even fuel.
- BECCS has some very important features to offer towards goals of improving energy security and climate change, but also considerable challenges.
- Negative public sentiment is a threat to otherwise enabling regulation and general sentiment for BECCS. This reduces the likelihood that we can start immediately to tap into the carbon negative benefits to BECCS.

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U.S. CONSUMPTION OF BIOENERGY WITH CARBON CAPTURE AND STORAGE

Efficiency of carbon capture and storage: There are three main methods of CCS:

1. Pre-combustion capture – Fuel is exposed to oxygen or air which emits a "fuel gas" composed mainly of carbon monoxide and hydrogen. The byproducts are then altered by a shift converter to produce CO_2 and additional hydrogen; the CO_2 is extracted, leaving a zero-carbon hydrogen-enriched fuel.
2. Post-combustion capture – Emissions from industrial processes may be dissolved in a chemical solvent; the CO_2 is then extracted from the liquid. CO_2 may also be separated using methods such as adsorption, separation with membranes, or cryogenic separation. Post-combustion capture is used to capture CO_2 from already existing emissions.
3. Oxyfuel combustion – Fuel is exposed to oxygen which results in a compound mainly made up of CO_2 and water; the CO_2 is then stored in a compression unit. (Gopalakrishnan, Hochman 2017)[1]
4. Capture efficiency of pre-combustion capture stands at about 85% and oxyfuel combustion stands at about 87.5%. Meanwhile, post-combustion capture CO_2 at an efficient rate of 95%. The International Energy Agency found that by 2050, CCS could decrease CO_2 emissions by 14%.[2]

What are the climate-related advantages of BECCS? The main fascination with BECCS is the technology's capability to "mop" up carbon; this capture and storage method effectively removes carbon dioxide from the atmosphere. Reversing the effects of climate change may only be successful with the implementation of bioenergy with carbon capture and storage. At the national level, manufacturing, agriculture, and energy sectors would benefit from the adoption of this new practice, whilst benefitting the public with cleaner air and cleaner water.

The 2016 Paris Agreement was signed into effect to make certain that the average increase in global temperatures would not exceed industrial levels by more than 2 degrees Celsius. Consequently, a worldwide emphasis was placed on reducing global temperatures; the greatest benefit that BECCS provides, with respect to climate change, is its potential to achieve net-negative carbon emissions. (Image- Statista) It is reasonably not possible to achieve the 2 degrees Celsius goal without BECCS. (Richard 2016).

- In pursuing BECCS, many individual energy production facilities are likely to be transitioning from use of a nonrenewable fuel source.
- There is a 66% likelihood of reaching the 2 degrees Celsius goal; 87% of these scenarios include large-scale BECCS deployment, as produced in connection with the Representative Concentration Pathway (RCP) of the International Panel on Climate Change[3]
- BECCS energy crops improve water quality.[4]
- Bioenergy carbon storage content is net neutral for BECCS in forestry, while storage content with offsets is carbon negative.
- Photosynthesis, in this case, is the key to carbon negativity because it influences how fast a tree grows.[5]
- United Nations Framework Convention on Climate Change (UNFCCC) believes the promise of net negative in BECCS outweighs any negative associations attributed to BECCS as a geoengineering effort.

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[1] Gopalakrishnan, Harahsa & Hochman, Gal. "Carbon capture and Storage Technologies: A survey of the literature." Presented at the Annual Aresty Meetings at Rutgers University, May 2017

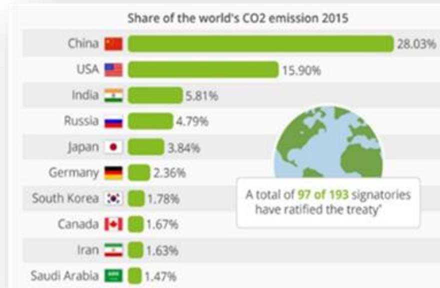
[2] International Energy Agency. *Technology Roadmap Carbon Capture and Storage*. 2013, pp. 1–60, *Technology Roadmap Carbon Capture and Storage*.

[3] Fridahl, Mathias. (2017). Socio-political prioritization of bioenergy with carbon capture and storage. *Energy Policy, 104*, 89-99. 2017.

[4] Richard, T. *Forest Carbon Management: Tradeoffs and Synergies among Bioenergy, Biomaterials, and Ecosystem Storage* (Scholarly project). 2016.

[5] Richard, T. *Forest Carbon Management: Tradeoffs and Synergies among Bioenergy, Biomaterials, and Ecosystem Storage* (Scholarly project). 2016.

Energy Security and BECCS
This creation of energy by biomass is rooted scientifically in the hydrocarbon content of biomass. Breaking down these hydrocarbons produces a considerable amount of energy that can be harnessed to maintain energy security, while minimizing pollution damages caused by fossil fuels.



BECCS generates electricity with a net carbon negative balance.
Fridahl (2017)[6] argued that BECCS produces energy at optimal levels, but only under the following conditions:

1. BECCS produced at a large-scale
2. Biomass sources and storage sites are co-located
3. Transportation infrastructure is well-developed
4. Competition for biomass is low

Problems with BECCS: BECCS climate benefits can be undermined by indirect emissions from deforestation and challenged by insurance issues from earthquakes associated with co_2 injections.[2]

- Some challenges associated with BECCS, in relation to energy security, are its variability based on several factors. Energy produced from BECCS can vary with availability of biomass.
- Some environmental NGOs argue that more BECCS bioenergy crops use can result in deforestation.[2] Some researchers additionally argue that it may take decades to millennia to recover the co_2 lost due to inefficient use of wood from the forest during bioenergy production. To this end, the use of agricultural and forestry residues is a promising avenue to pursue, which does not result in deforestation.
- BECCS is threatened by a negative public and UFCCC delegate preference for carbon capture and storage as well as not-in-my-backyard sentiments from the pubic and environmentalists, due to worries about possible leakage. [2]

Public perception and preference can have an indirect effect of the climate.

[6] Fridahl, Mathias. (2017). Socio-political prioritization of bioenergy with carbon capture and storage. *Energy Policy, 104*, 89-99. 2017.
[7] Zimmer, Carl. "An Ominous Warning on the Effects of Ocean Acidification." *Yale E360*, Yale School of Forestry & Environmental Studies, 15 Feb. 2010, e360.yale.edu/features/an_ominous_warning_on_the__effects_of_ocean_acidification.