What is stopping Carbon Capture Utilization and Storage from closing the carbon loop?

In spite of urgent calls for action to carbon dioxide emissions to mitigate the effects of climate change, little attention and funding (relative to renewable energy or energy efficiency measures) has been given to a technological solution that can take this greenhouse gas from a concentrated source or directly from the atmosphere, and use or sequester it. In theory, Carbon Capture, Utilization and Storage (CCUS) can be considered a viable option to reduce the amount of anthropogenic greenhouse gases emissions. In reality, there are significant technological, political, economic, and practical hurdles for CCUS to work on an effective scale.

Environmental Opposition to CCUS
- Enabler of continued use of fossil fuels and "entrenched regime". May induce carbon leakage
- CCS has historic support from the coal industry
- Diversion of resources that include public R&D from cleaner technologies

Uncertainty
- No international consensus on cooperation of how to mitigate climate change
- Regulatory and legal considerations for storage and transport
- Intellectual property rights
- Difficult to insure

Risks
- Release of CO_2 back into the atmosphere. Difficult to monitor
- Local risks: ground heave, induced seismicity, contamination of underground drinking water

Costs
- There are limited commercial uses for captured carbon dioxide, and this technology requires massive upfront investment
- Monitoring, verification and assessment of storage can be extremely expensive
- There is no understanding of the "true cost". Estimates of air capture range from $30/tCO_2$ to $600t/CO_2$

The social cost of carbon is still not developed

There is no global consensus on the price of reducing carbon dioxide as a global public good. Considering the social cost of carbon, or the net present value of climate impacts due to increasing emissions by one tonne, one can consider society's willingness to pay for reducing carbon emissions.

Study	Value ($/tCO_2$)
Stern (2007)	$85/tCO_2$
Nordhaus (2008)	$12/tCO_2$
Obama Administration (2013) for year 2020	$43/tCO_2$
Reference Values	
EU emissions trading price (2014)	$7/tCO_2$ (and falling)
RGGI auction price	$3/tCO_2$
British Columbia carbon tax	$30/tCO_2$
Australia carbon tax	$23/tCO_2$ (tenuous future because of new government and link to EU ETS prices)

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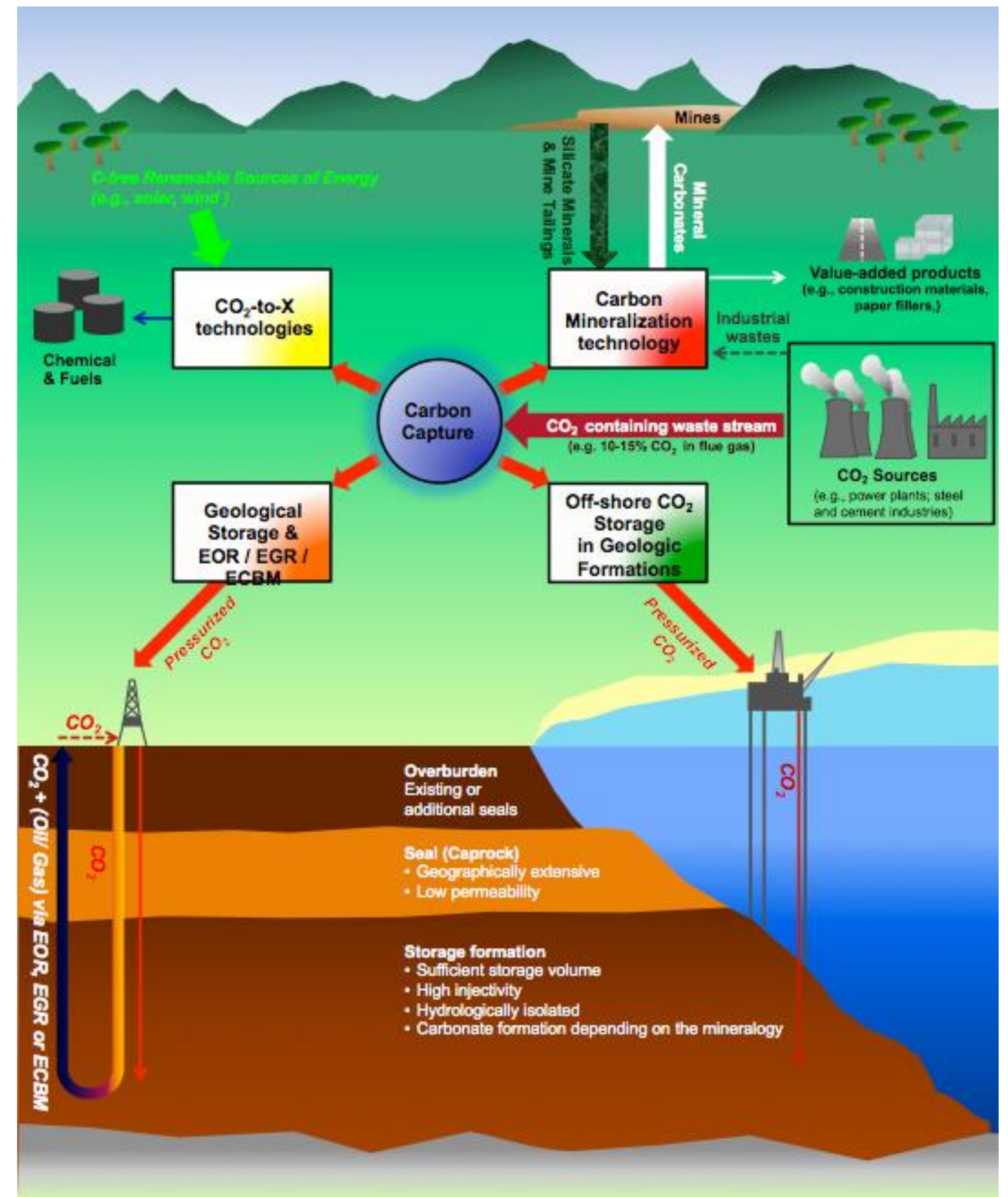
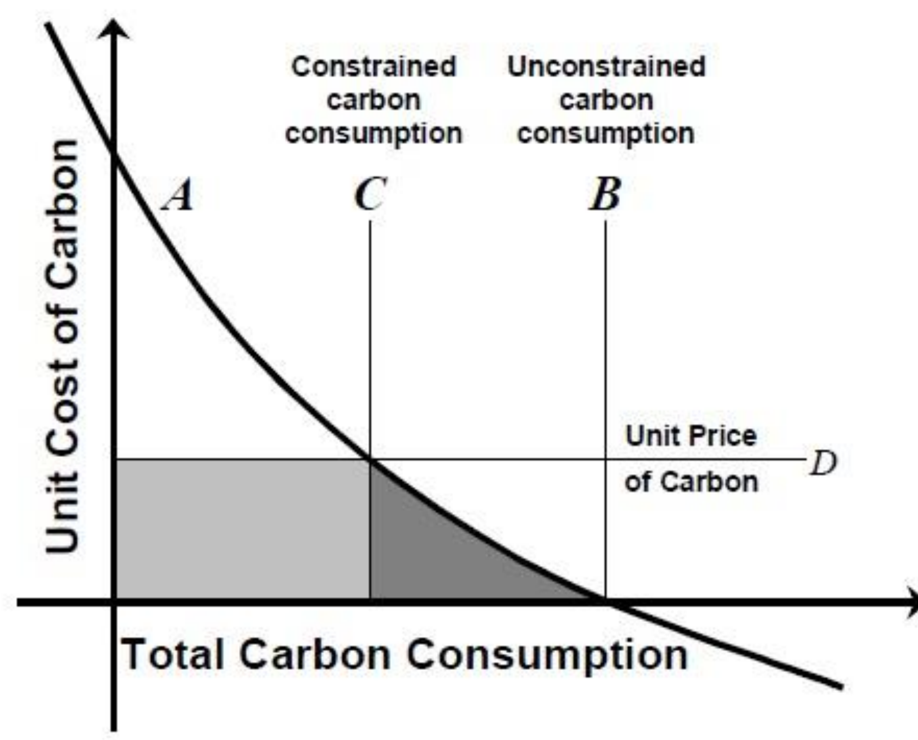
Current and future prospects

The image on the right displays sinks, fluxes, and uses for carbon dioxide captured from a concentrated source. This type of stack capture is a more conventional form of CCUS. The greatest benefit from captured carbon dioxide is currently a process known as Enhanced Oil Recovery (EOR). While EOR does allow oil previously inaccessible to be used, thereby increasing the amount of new fossil fuels released into the atmosphere, it is able to sequester more carbon dioxide than is emitted by about 30% and provides room for the future commercialization for the capturing and sequestering technology.

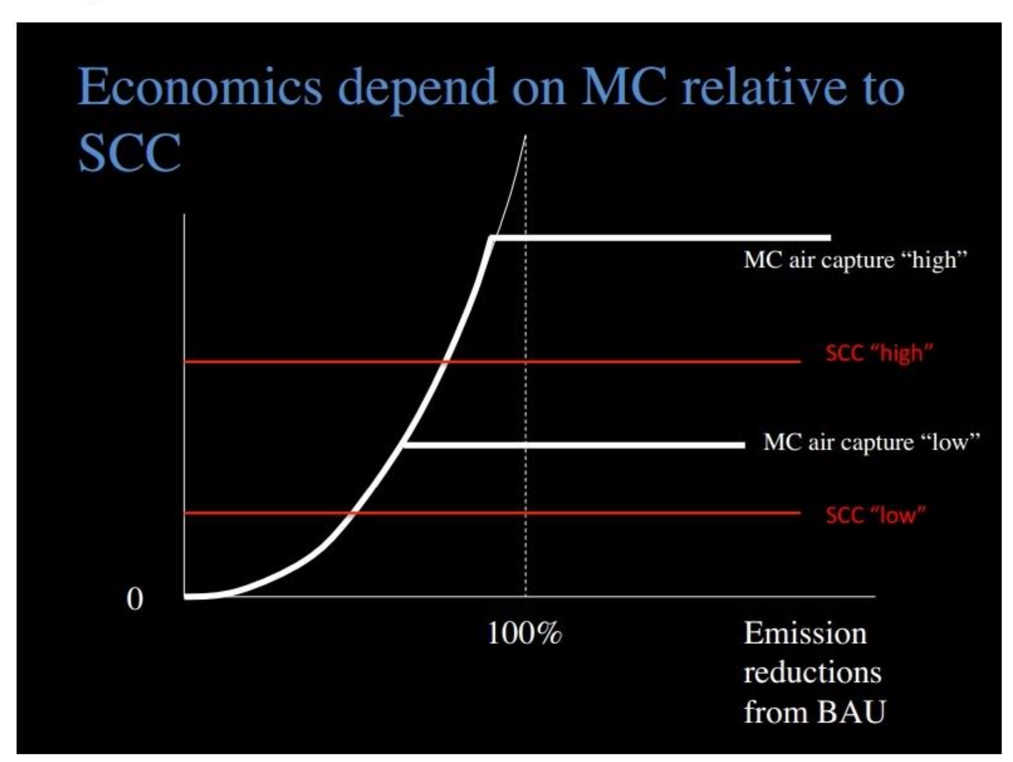
While the use of carbon dioxide to create fuels, such as methanol is another effective means of capturing and using carbon dioxide (thereby obviating the need for extraction of fossil fuels), it does not work to close the loop, but simply maintain the amount of carbon consumed and emitted.





A free market approach to limiting emissions with direct air capture:

Curve A represents the marginal cost of avoiding a unit of carbon transfer. With a permit scheme to limit the amount of carbon introduced into the carbon pool, holding D constant would permit A to reach C. Lowing the price of carbon direct air capture would flatten line A. The darkened area represents the actual cost to achieve the given reduction. By reducing the number and increasing the cost of permits, a gradual scheme that allows a carbon neutral paradigm to be achieved.

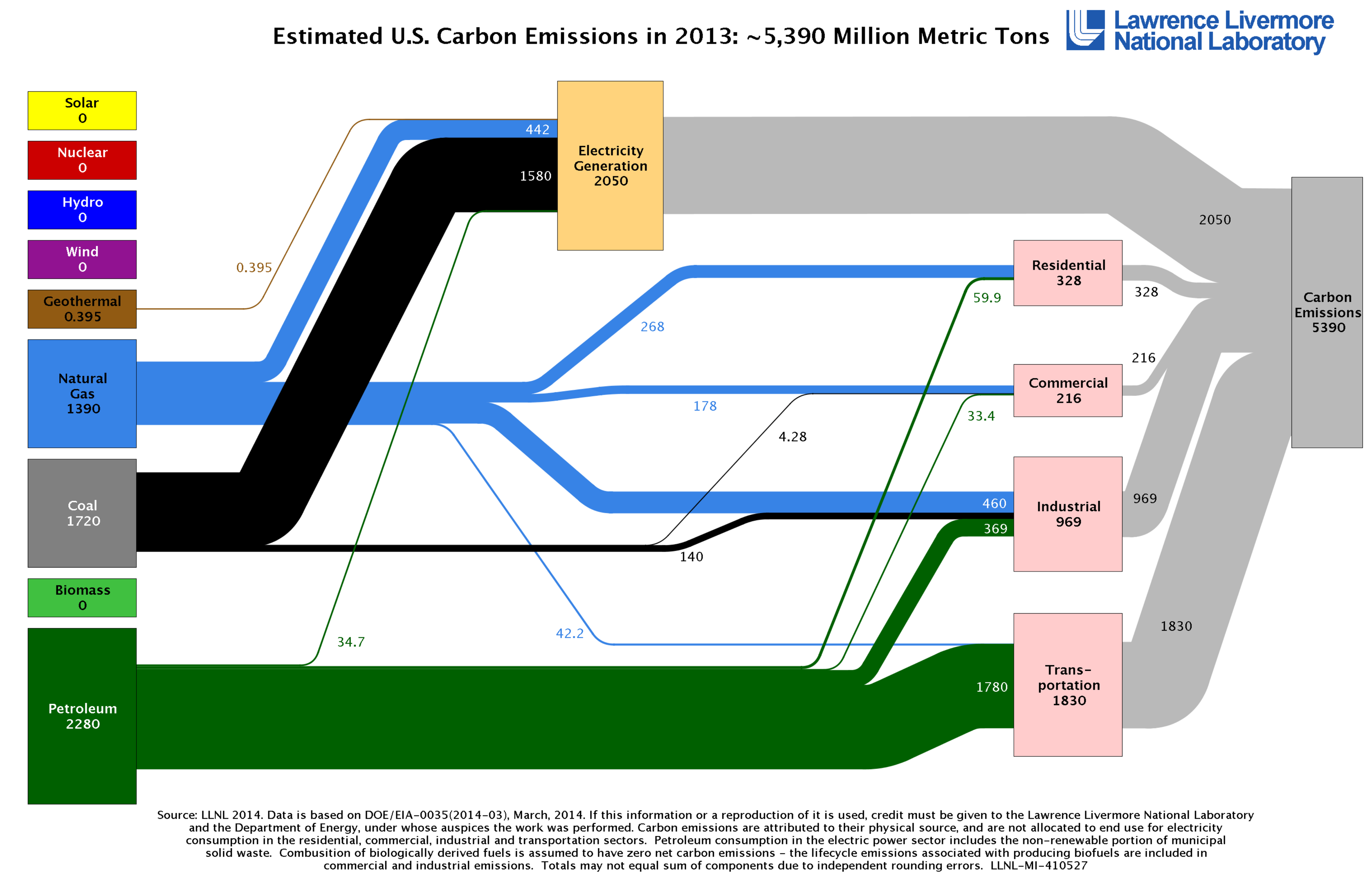


This displays two graphs of the social cost of carbon and how Direct Air Capture be used. Under the two scenarios, it will be used if the social cost of carbon is greater than the social marginal cost of another unit of CCUS. ($SCC > MC_{CCS}$). Once the acceptable threshold of carbon emissions to the atmosphere has been surpassed, the appeal for this backstop technology becomes quickly amplified. This is because this technology gives the opportunity to fix emissions levels at a defined value, or to adjust emissions and CO_2 sinks to fix atmospheric concentration of CO_2.

Why the United States pursue this technology

Ceasing the global consumption of fossil fuels is unrealistic

Several countries, including China, the United Kingdom, and Australia view CCUS as integral to carbon neutral economies. Implicit in these assumptions are the continued use of fossil fuels as an abundant and cheap source of energy that will continue to be used and consumed for the good of the country and international cooperation is detrimental to that country's development. Not investing in CCUS on a massive scale will leave the US behind, and incapable of becoming carbon neutral, or a leader in mitigating climate change. In the majority of scenarios reported by the IPCC to mitigate climate change, CCUS is included.



Direct Air Capture can compensate mobile CO2 emissions

The image above shows the carbon emissions per million metric ton in the United States from various sources. Of the various opportunities to reduce emissions from these sectors, direct air capture could provide a route for closing the carbon loop in the transportation sector, which due to the need for high energy density fuels, has proven to be one of the most difficult sectors to decarbonize. Under this scenario, synthetic fuels would displace fossil derived hydrocarbons thereby reducing the emissions associated with this sector.

Carbon Capture Utilization and Storage is the only technology that allows up to clean up after ourselves

Because of limited scope of solutions (such as reforestation), and the inability of emissions reductions to actually reduce the amount of carbon dioxide in the atmosphere, only CCUS provides the long term considerations that allows sequestration of greenhouse gases released from fossil fuels

	Emission reductions	Adaptation	Climate engineering	Air capture
International cooperation?	Yes	No	No	No
Trade leakage?	Yes	No	No	No
Spillovers	Yes (+)	No	Yes (+/-)	Yes (+)
Addresses root cause of problem	Yes	No	No	Yes
Scale limited?	Yes	Yes	No	No
Acts quickly	No	Yes	Yes	No
Cost of limiting temperature change	High	--	Very low	Very high
Governance problem?	No	No	Very much	A little

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