Wet NET

By John Benson

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1. Introduction

"Have a Plan B, and maybe even a Plan C. Because unexpected changes are most difficult to handle when we don't have a backup."

— Germany Kent, American Print and Broadcast Journalist

Having looked at the subject of climate change quite a bit, there are many ways we can fix this problem, IF we work on it diligently. However humans have a habit of doing really dumb things, like <u>not</u> fixing a big problem we created, one that has already screwed up our climate big time, and is likely to create even worse problems in the future.

And thus my argument for all of the Plan Bs and Plan Cs we can find.

Most of my readers know that NET stands for Negative Emissions Technology. I have argued for carbon dioxide negative emissions technology (five NETWORKS posts so far, the last two are described and linked below). I've; argued against methane NET (single post, described and linked below the NETWORKS posts).

New NETWORKS, Part 5: Oxi-Fuel Combustion: *NETWORK is my term for "Negative Emissions Technologies." These are the most valuable of all renewables. They not only do not add greenhouse gas (GHG) to the atmosphere, but they have the potential of removing GHG from the atmosphere while in some cases providing other benefits.*

The NETWORK described by this post is (sort of) BECCS, but the "CC" really superfluous because no carbon capture is required. The output of the process is pure CO_2, water vapor and heat that can be used to produce electricity or provide process heat.

https://energycentral.com/c/cp/new-networks-part-5-oxi-fuel-combustion

New NETWORKS, Part 4 – Peridotite & Soil: *Mantle Rocks are minerals that normally only exist in Earth's Mantle, a layer that is normally starts 4 miles below the surface. Rocks in this layer normally stay in this layer, but in a few locations they rise to the surface. That is the case with peridotite.*

Mantle peridotite reacts with H_2O and CO_2 near the Earth's surface. Note the CO_2.

If Mantle Rocks might be thought of as an exotic material, soil is definitely not. It's everywhere: in our yards, forests, deserts, plains mountains, everywhere. We will talk about a particular type of soil, that which is used for agriculture (it too is pretty common). This soil probably has the capability to store more CO_2 than peridotite, if we modify our farming practices to do so.

These two methods of Negative Emissions Technology (NET) will be reviewed in this post.

https://energycentral.com/c/ec/new-networks-part-4-%E2%80%93-peridotite-soil

NETMeth – Not: *Hopefully this will be a short post. I am mainly writing it to address a proposal that I do not think is a good idea. This is mainly because I read about it in a periodical that I greatly respect, and I really do not wish to hear others saying that it sounds like a great proposal.*

The proposal was in an article in the Nov 5, 2021 issue of Science, and it was to use negative emissions technology to capture methane. The good news is that this article pointed out several problems with this proposal.

https://energycentral.com/c/ec/netmeth-%E2%80%93-not

The title NET are carbon dioxide negative emissions technologies that involve the oceans. I believe we should evaluate these, identify those that might work, don't involve any serious risks, and most should be put on the shelf as plans B, etc.

This post lists Wet Nets and describes their current state of readiness and efforts to improve them.

2. Iron Fertilization

In January 2009, a German research ship set out for the Southern Ocean carrying 6 tons of iron and a boat load of controversy. The iron was meant to trigger a massive phytoplankton bloom that would suck carbon dioxide (CO_2) from the air, but environmentalists objected, viewing the trial as a reckless form of geoengineering. The German government briefly suspended the work, before letting it go ahead. It would be the last iron fertilization experiment for more than a decade.[1]

This experiment was called LOHAFEX.

A cyclonic eddy centered on 48°S, 16°E was selected for fertilization. The experiment began on India's Republic Day (26 January 2009). Ten tonnes of ferrous sulphate dissolved in seawater was spread over an area of 300 square kilometers, and the patch created was monitored for 38 days to investigate the effects of iron addition on marine biogeochemistry and ecosystem. Another iron addition of similar magnitude was done two weeks later. It was expected that iron addition would trigger algal bloom leading to sequestration of carbon dioxide from the atmosphere…[2]

LOHAFEX was not the first experiment of its kind. In 2000 and 2004, comparable amounts of iron sulfate were discharged from the same ship (EisenEx experiment). 10 to 20 percent of the algal bloom died off and sank to the sea floor. This removed carbon from the atmosphere, which is the intended carbon sink.

As expected iron fertilization led to development of a bloom during LOHAFEX, but the chlorophyll increase within the fertilized patch, an indicator of biomass, was smaller than in previous experiments. The algal bloom also stimulated the growth of zooplankton that feed on them. The zooplankton in turn are consumed by higher organisms…

[1] Warren Cornwall, Science, "To draw down carbon, ocean fertilization gets another look," Dec 17, 2021, https://www.science.org/content/article/draw-down-carbon-and-cool-planet-ocean-fertilization-gets-another-look#

[2] Wikipedia article on LOHAFEX, https://en.wikipedia.org/wiki/LOHAFEX

In contrast to the other experiments the uptake of the algae by zooplankton left no relevant organic carbon to sink to the ocean floor. Thus, the applied iron did not contribute to the sequestration of carbon dioxide from the atmosphere.

The key here is that a particular experiment in iron ocean fertilization failed, however some earlier experiments had succeeded. Clearly, at that point we did not understand enough about iron ocean fertilization to elevate this into an effective technique, but at least we learned something.

Rigorous tests of the strategy are critical, says Ken Buesseler, a biogeochemist at the Woods Hole Oceanographic Institution and a co-author of the National Academies of Sciences, Engineering, and Medicine (NASEM) panel report. "I think it is going to happen with or without the science," Buesseler says. "My fear is we see this commercialized before we know some of the fundamentals about the ocean response."[1]

… Buesseler is encouraged by recent computer modeling, published by Doney, Siegel, and colleagues in Environmental Research Letters, showing nearly one-third of the carbon captured near the ocean surface by events such as plankton blooms should sink to the deep ocean. Ocean-fertilization strategies could be viable "if we can get even 10% down deep enough," he says.

But skeptics note that a recent survey of 13 past fertilization experiments found only one that increased carbon levels deep in the ocean. That track record is one reason why making iron fertilization a research priority is "barking mad," says Wil Burns, an ocean law expert at Northwestern University.

…David King, head of the Centre for Climate Repair at the University of Cambridge, is ready to test these politically charged waters. Next summer, working with scientists at India's Institute of Maritime Studies in Goa, he plans to spread iron-coated rice husks across a swath of the Arabian Sea, to learn whether suspending the nutrient for longer can spark a bloom with less iron.

To head off environmental concerns, King plans to confine the work within a giant plastic bag running from the surface to the sea floor several kilometers below. "There's an enormous amount of naysaying going on," King says. "There are many, many people saying let's leave the oceans alone, as if we haven't already interfered with them."

I happen to agree with Mr. King. Iron ocean fertilization could be rapidly deployed in a screaming panic, but we need a much better understanding of this very complex process before we can optimize it and make sure it will be effective. As I said above, do safe experiments (which I believe Mr. King's is), learn, optimize, and then, if it looks promising, put it on the shelf for the next Plan B.

3. Other Wet NETs

The following are other potential negative emissions technologies that involve the oceans. Some are low risk because the mimic natural processes, and others have the potential for unintended consequences, and thus need to be better understood.

3.1. Coastal Technologies

There are basically two directions one can go from the coast – offshore or onshore. Each of these has at least one Wet NET.

3.1.1. Onshore

Some wetlands perform better under pressure. A new study revealed that when faced with sea-level rise, coastal wetlands respond by burying even more carbon in their soils.[3]

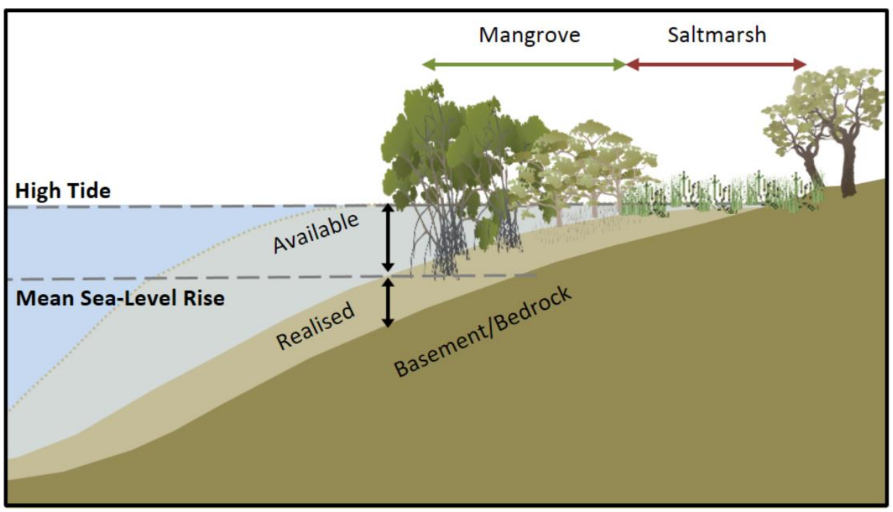
Coastal wetlands—which include marshes, mangroves and seagrasses—already store carbon more efficiently than any other natural ecosystem, including forests. The latest study, published March 7 (2019) in the journal Nature, looked at how coastal wetlands worldwide react to rising seas and discovered they can rise to the occasion, offering additional protection against climate change.

"Scientists know a fair amount about the carbon stored in our local tidal wetlands, but we didn't have enough data to see global patterns," said Pat Megonigal, a co-author and soil scientist at the Smithsonian Environmental Research Center.

To get a global picture, scientists from Australia, China, South Africa and the U.S. pooled data from 345 wetland sites on six continents. They looked at how those wetlands stored carbon for up to 6,000 years and compared whether sea levels rose, fell or stayed mostly the same over the millennia.

For wetlands that had faced rising seas, carbon concentrations doubled or nearly quadrupled in just the top 20 centimeters of soil. When the scientists looked deeper, at 50 to 100 centimeters beneath the surface, the difference hit five to nine times higher.

The extra boost comes because the carbon added to wetland soils by plant growth and sediment is buried faster as wetlands become wetter. Trapped underwater with little to no oxygen, the organic detritus does not decompose and release carbon dioxide as quickly. And the higher the waters rise, the more underwater storage space exists for the carbon to get buried.



Wetlands store much of their carbon by burying sediments underwater, which are often loaded with organic, carbon-rich matter. When tidal wetlands flood from tides or sea-level rise, sediment accumulates above the bedrock floor. The higher the waters rise, the more space exists for sediment to build up.
(Credit: University of Wollongong)

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[3] Patrick Megonigal, Smithsonian Environmental Research Center, "As Sea Level Rises, Wetlands Crank Up Their Carbon Storage," March 6, 2019, https://serc.si.edu/media/press-release/sea-level-rises-wetlands-crank-their-carbon-storage

…"They may be the sleeping giants of global carbon sequestration," said lead author Kerrylee Rogers of the University of Wollongong in Australia. Half of the world's tidal marshland grows along the coastlines of southern Africa, Australia, China and South America. If those wetlands doubled their carbon sequestration—as other wetlands in the study did in response to sea-level rise—they could sequester another 5 million tons of atmospheric carbon every year. That is the equivalent of taking more than a million cars off the road.

The trick, of course, is to ensure wetlands do not drown and disappear if waters rise too quickly.

"Preservation of coastal wetlands is critical if they are to play a role in sequestering carbon and mitigating climate change," Rogers said…

The above described process is both a powerful negative emissions process, and a safe one. However it is <u>not</u> a free lunch. Scientists need to better understand the above-described processes, identify the best coastal areas for optimal wetland-development, preserve these and provide any resources the wetlands need to sequester the maximum amount of carbon.

3.1.2. Offshore

Most people don't know that my home state (California) has massive forests offshore and underwater. These are our amazing Kelp Forests. Just as we have huge Redwoods in our on-shore forests, we have Bull Kelp Forests north of San Francisco and Giant Kelp forests to the south. But these are fragile ecosystems, and they are dying.

Satellite imagery shows that the area covered by kelp forests off the coast of Northern California has dropped by more than 95 percent, with just a few small, isolated patches of bull kelp remaining. Species-rich kelp forests have been replaced by "urchin barrens," where purple sea urchins cover a seafloor devoid of kelp and other algae.[4]

A new study led by researchers at UC Santa Cruz documents this dramatic shift in the coastal ecosystem and analyzes the events that caused it. This was not a gradual decline, but an abrupt collapse of the kelp forest ecosystem in the aftermath of unusual ocean warming along the West Coast starting in 2014, part of a series of events that combined to decimate the kelp forests.

Published March 5 in Communications Biology, the study shows that the kelp forests north of San Francisco were resilient to extreme warming events in the past, surviving other strong marine heatwaves and El Niño events. But the loss of a key urchin predator, the sunflower sea star, due to sea star wasting disease left the kelp forests of Northern California without any predators of sea urchins, which are voracious grazers of kelp…

[4] Tim Stephens, UC Santa Cruz News center, "The collapse of Northern California kelp forests will be hard to reverse," March 5, 2021, https://news.ucsc.edu/2021/03/kelp-forests-norcal.html

"There have been big changes before, when a strong El Niño has reduced the kelp canopy dramatically, but in the past it's always come back," said coauthor Raphael Kudela, professor and chair of ocean science at UC Santa Cruz. "The loss of resiliency is what made this time different—the combination of ocean warming and the loss of the sea stars allowed the urchins to take over."

…Kelp forests declined all along the California coast, but not to the same extent as in Northern California. Bull kelp is an annual species that regrows each year, which may make it more sensitive to these stressors than giant kelp. But another critical difference in Northern California is the absence of other urchin predators such as sea otters, which have enabled patches of healthy kelp forest to persist in Monterey Bay, for example.

"Sea otters haven't been seen on the North Coast since the 1800s," McPherson said. "From what we observed in the satellite data from the last 35 years, the kelp had been doing well without sea otters as long as we still had sunflower stars. Once they were gone, there were no urchin predators left in the system."

What that means for the future, she said, is that the prospects for recovery of the Northern California kelp forests are poor unless sunflower sea stars or some other urchin predator returns to the system. Even if temperature and nutrient conditions are good for kelp growth, new kelp plants will have a hard time getting established in the midst of the urchin barrens…

"There's a lot of research and discussion now about the best management strategies for the future," she said. "It's important to understand and monitor the whole system. If we're going to undertake restoration efforts, we need to make sure to do it when the temperature and nutrient conditions are right for the kelp."

Kudela said ocean temperatures are beginning to cool down along the coast, after remaining above normal since 2014. "This year we are finally seeing ocean temperatures starting to cool off, so we're hoping that it reverses naturally and the kelp is able to take off again," he said…

Kelp forests sequester a large amount of carbon. Helping the Northern California kelp forests recover is totally safe, since, historically, these forests have been here for millennia. Only a combination of climate change (warming oceans) and greedy ancestral fur-traders (who basically completely wiped out the Sea Otters in the 1800s) are destroying them. I would suggest we (California) start a program to relocate Sea Otter populations into the Northern California areas devastated by urchin barrens.

4. Wish List

I ran across several of these and found one that was viable, concise, and fit well with the above information. Also the institution that published it is highly respected. This is below:

The report explores six basic approaches:[5]

Nutrient Fertilization: *This would involve adding nutrients such as phosphorus or nitrogen to the ocean surface to increase photosynthesis by phytoplankton. A portion of phytoplankton sink when they die, so this would increase the transfer of carbon to the*

[5] Earth Institute, Columbia Climate School, "Oceans Could Be Harnessed to Remove Carbon From Air, Say U.S. Science Leaders," Dec 9, 2021, https://news.climate.columbia.edu/2021/12/09/oceans-could-be-harnessed-to-remove-carbon-from-air-say-u-s-science-leaders/

deep ocean, where it can stay for a century or longer. The report says there is medium to high confidence that this approach would be effective and scalable, with medium environmental risks and with low scale-up costs beyond the costs for environmental monitoring. The report estimates $290 million would be needed for research including field experiments and tracking the amount of carbon sequestered as a result.

Author's Comment: Similar to Iron Fertilization.

Seaweed Cultivation: *Large-scale seaweed farming that transports carbon to the deep ocean or into sediments would have medium efficacy and medium to high durability for removing atmospheric CO_2, the report says. But there would be medium to high environmental risks. The report estimates $130 million for research to understand technologies for efficient large-scale farming and harvesting, the long-term fates of seaweed biomass, and the environmental impacts.*

Ecosystem Recovery: *Protection and restoration of coastal ecosystems and the subsequent recovery of fish, whales and other marine wildlife could help capture and sequester carbon. It comes with the lowest environmental risks among the assessed approaches, and with high co-benefits, say the authors. The report says it could have low to medium efficacy. It estimates $220 million for research, including to study effects on macro-algae, marine animals and marine protected areas.*

Author's Comment: Restoration of our Kelp Forests is one flavor of this.

Ocean Alkalinity Enhancement: *This approach chemically alters ocean water to increase its alkalinity in order to enhance reactions that take up atmospheric CO_2. The report says there is high confidence in its efficacy. Ocean alkalinity enhancement carries medium environmental risks and medium to high scale-up costs. The report estimates $125 million to $200 million for research, including field and laboratory experiments to explore the impact on marine organisms.*

Electrochemical Processes: *Passing an electric current through water could either increase the acidity of seawater in order to release CO_2, or increase its alkalinity to enhance its ability to retain it. There is high confidence in its efficacy, and medium to high confidence in its scalability. However, this approach carries the highest scale-up cost of any of the approaches assessed, and medium to high environmental risks. The report estimates $350 million for research, including for demonstration projects and to develop and assess improved materials that would be needed.*

Artificial Upwelling and Down-welling: *Upwelling moves cooler, more nutrient- and CO_2-rich deep water to the surface, stimulating the growth of phytoplankton. Down-welling moves surface water and carbon to the deep ocean. The report says there is low confidence in the efficacy and scalability of these approaches, and that they carry medium to high environmental risks, along with high costs and challenges for carbon accounting. The report estimates $25 million would be needed for research, such as technological readiness and limited and controlled ocean trials.*

Final Author's Comment: The report mentioned above is from another highly respected organization: The National Academies of Sciences, Engineering, and Medicine. This report is linked in the above reference 5.