In Support of a Renewable Energy and Materials Economy (REME): A Global Green New Deal (GGND) that Includes Arctic Sea-Ice Triage and Carbon Cycle Restoration

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For Presentation to Union for Radical Political Economics (URPE) Panel:
"Capitalism Post-Coronavirus"
ASSA/AEA Annual Meetings
January 5, 2021
Chicago, IL

We Need to Learn a Lesson from our (US) Disastrous Covid-19 Response and Implement Arctic Sea-Ice Climate Triage Now!

- Biden has even built his campaign around the slogan “build back better”.
- But unfortunately, “building back” is not going work as we face the risk of greater and more lasting damage to our environment if we do not prevent the imminent melting of the Arctic.
- We need to learn the lesson of the pandemic and take urgent climate *triage* measures now to prevent this from happening.
- We need to act on this now even as we also act to ramp up at an emergency pace (just as with vaccine development) climate mitigation, adaptation, and carbon cycle *restoration* efforts.

A Global Green New Deal (GGND) is a Critical Transformative Goal

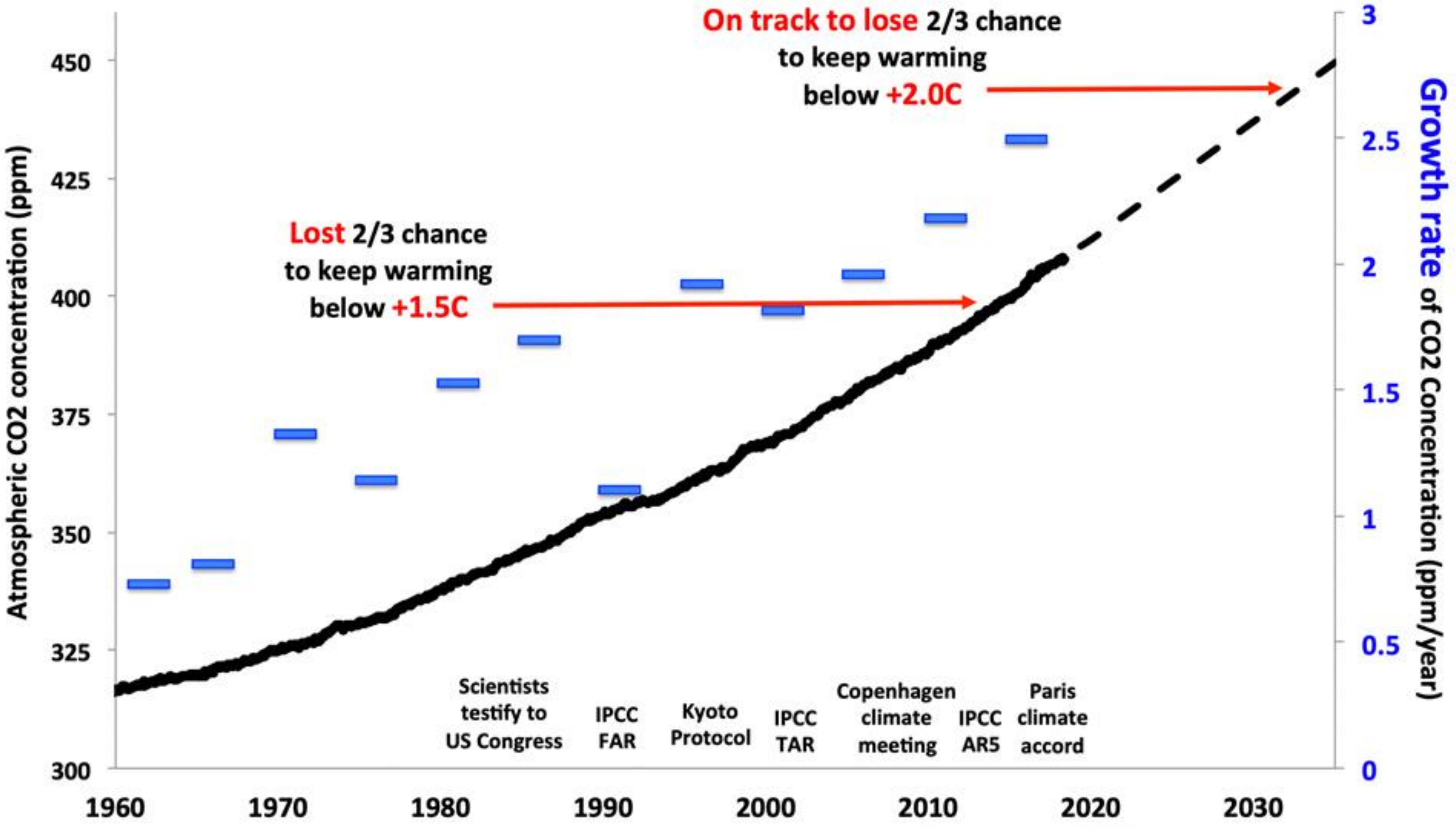
- A Global Green New Deal (GGND) could be funded by the US alone, by creating dollars at roughly the 2008-2011 rate (which though historic, is considerably less than the 2020 rate), could fund for almost thirty-years (Baiman, 2020: Sections 2 and 6).
- In fact, a case could be made that as the current custodian of the world's global fiat currency, the US government has a responsibility to employ its unique monetary power to help all of humanity by issuing dollars to restore a stable global climate (Baiman, 2020).
- Similarly, Stopping climate change could cost less than fighting covid-19" (King and Parnell, 2020). King and Parnell also call for immediate climate *restoration*, including Direct Air Capture, in addition to *mitigation* and *adaptation*.

But GGND Needs to Include Practical Climate, *Triage* and *Restoration*

- If we do not prevent the Arctic Sea-ice from melting through urgent climate triage measures and do not commence to rapidly implement a carbon cycle carbon restoration that begins with Carbon Direct Removal (CDR), our efforts to prevent accelerating climate catastrophe through *mitigation* and *adaptation* alone will fail.
- We also need to once and for all stop thinking of climate change and GHG emissions as a *flow-reduction* problem, and to correctly frame the problem in *stock-capacity* waste-management, carbon-cycle closure terms.
- Need for CDR was officially acknowledged in 2018 as the IPCC stated that CDR was necessary to keep below (an obviously too high given the melting Arctic) 2 degrees Celsius guard rail.

As the Climate Crisis will Not Wait for Fundamental Social Transformation

- There is no question that over the long-term we must work to: address our existing unconscionable environmental justice issues:
  - Stop despoiling and destroying natural habitats; work on medium term soil and water-cycle climate regeneration (Baiman, 2020)
  - Reduce human population encroachment into hitherto distant viral and bacterial pools increasing the incidence of global pandemics.
- The Long and medium-term social transformations that we on the left envision as a solution to the climate crises require a fundamental reorientation of our political economy, including both *forces* (technologies) and *relations* (social organization) of production that will likely take decades, if not centuries, to accomplish on a global scale.



The **thick black line** is the atmospheric concentration of carbon dioxide measured from Mauna Loa Observatory, after removing the cyclical seasonal effect. **Blue bars** indicate independently sampled points of a 5-year running average of the yearly global CO_2 growth rates estimated by NOAA. Red arrows point to critical points with respect to the Paris targets of 1.5°C and 2.0°C.

This Should Not be Viewed as a Fundamental Political or Moral Failure of our Species.

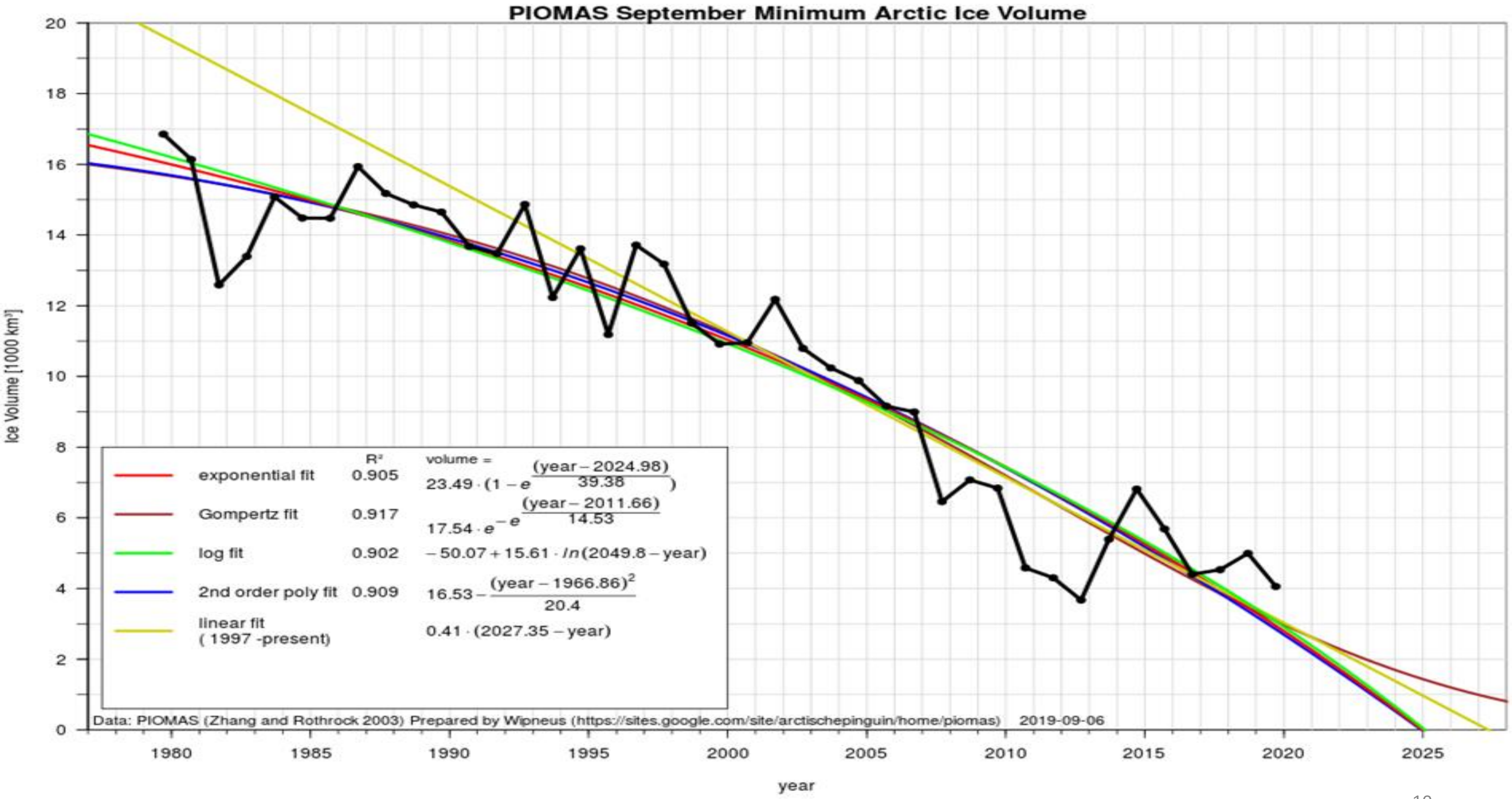
- Modern civilization is dependent on energy growth and fossil fuels remain the most economical and widely available principal source of energy, and raw material inputs, for much of modern industrial civilization .
- This is slowly changing. Solar is catching up and, in many cases, is less expensive than fossil fuel in terms of unit energy cost (even without taking into account the externality costs of carbon dumping that most fossil fuel producers do not currently bear), but not in-terms of dispatchability and portability.
- Carbon-negative cement and concrete, and carbon-based substitutes for steel and aluminum, as well as organic-carbon based substitutes for feed and fertilizer, currently exist or are being developed.
- But especially for developing countries, and particularly those who have large oil or other fossil fuel deposits and national resource-based economies that are dependent on fossil fuel or natural resource exports – often by public companies, there are no other current viable options. As discussed below, a REME economy will develop these alternatives but not overnight.

Carbon-Free Economy Framing May Have Become an Obstacle to Practical Progress

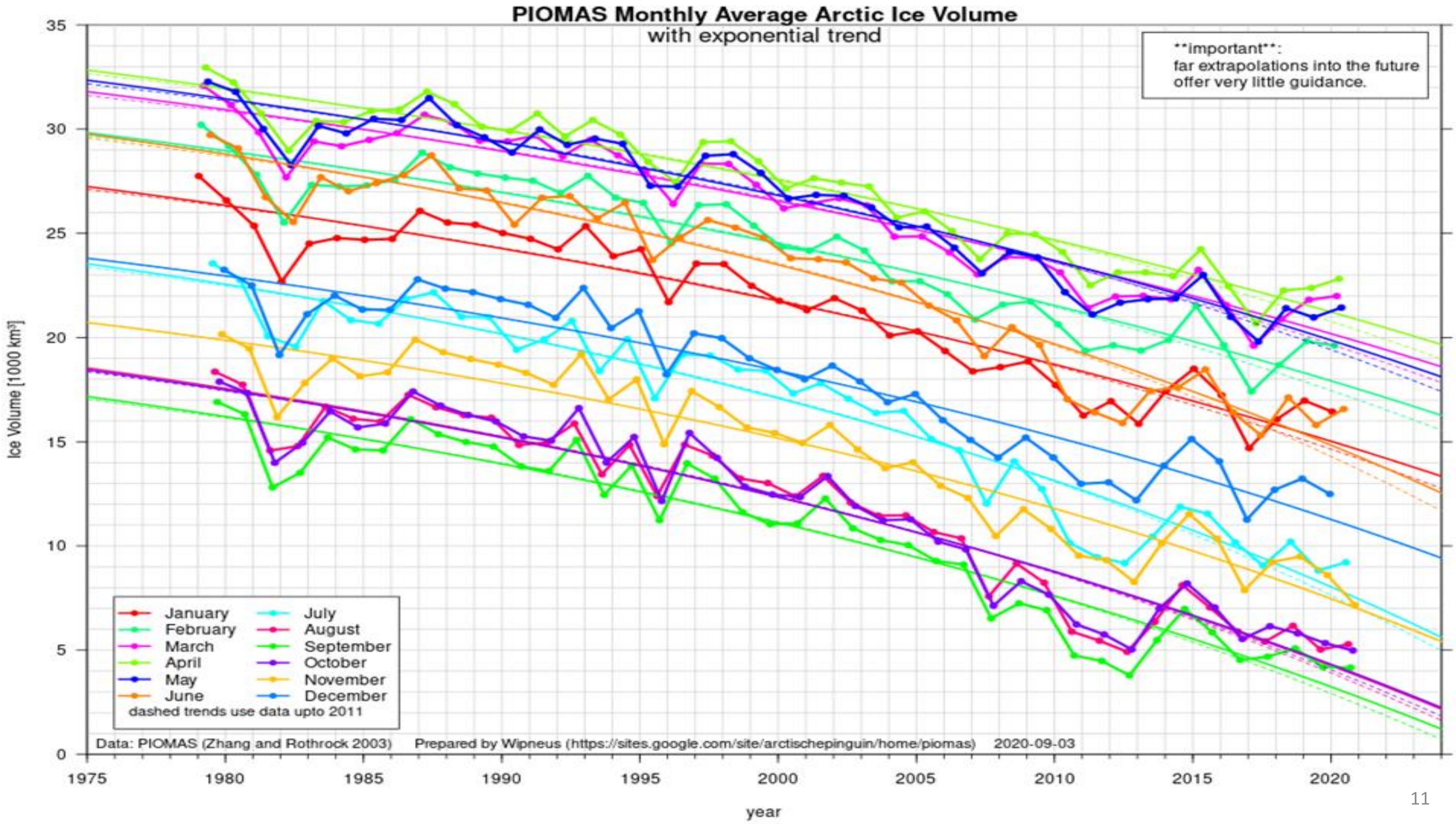
- This framing needs to be replaced with a practical and realistic waste management and carbon cycle framework.
- We need to be pointing out that climate change is fundamentally a closing the carbon cycle (REME) reuse problem or, as it is likely to be impossible to reuse as much carbon as we need to sequester in the coming decades, a near-term sequestering problem.
- A stable climate can and must, due to the time urgency, be restored within existing capitalist social and economic systems, and with current and evolving technologies.
- We need a GGND that includes Arctic Sea Ice climate triage and Carbon Cycle and that that works toward a REME technological and economic transformation by preventing civilization and species climate catastrophe and eliminating or reducing energy and materials scarcity, and allows for a democratic socialist political and economic transformation over the long term.

Melting Arctic Sea-Ice is the First Major Climate Tipping Point

- Arctic sea-ice melting would be roughly equal to that of 17.3 years of global green-house gas (GHG) emissions relative to the 2016 base level of CO2 in the atmosphere that would blow through "carbon budget".
- Increased solar polar heating from the loss of reflectivity will no longer be absorbed by melting ice. A "warm water time bomb" has already been discovered accumulating under the Arctic that is accelerating ice ice.
- "Arctic amplification", or disproportionate Arctic warming relative to mid-latitudes weakens the Polar Jet and Gulf and may cause the cold center of the Jet stream to move toward northern Greenland, 17 degrees latitude south of the north pole, exacerbating extreme planetary climate crisis.
- Warming Arctic atmospheric and ocean water, increased Arctic humidity are accelerating the risk Greenland Ice Sheet melting and increased permafrost melt leading to amplified carbon dioxide and methane GHG release.



PIOMAS September Minimum Arctic Ice Volume
Ice Volume [1000 km³]
year
R²
volume =
exponential fit 0.905 23.49 · (1 − e^((year − 2024.98)/39.38))
Gompertz fit 0.917 17.54 · e^(−e^((year − 2011.66)/14.53))
log fit 0.902 −50.07 + 15.61 · ln(2049.8 − year)
2nd order poly fit 0.909 16.53 − (year − 1966.86)²/20.4
linear fit
(1997 -present)
0.41 · (2027.35 − year)
Data: PIOMAS (Zhang and Rothrock 2003) Prepared by Wipneus (https://sites.google.com/site/arctischepinguin/home/piomas) 2019-09-06


PIOMAS Monthly Average Arctic Ice Volume
with exponential trend
important:
far extrapolations into the future
offer very little guidance.
Ice Volume [1000 km³]
year
January
February
March
April
May
June
July
August
September
October
November
December
dashed trends use data upto 2011
Data: PIOMAS (Zhang and Rothrock 2003)
Prepared by Wipneus (https://sites.google.com/site/arctischepinguin/home/piomas)
2020-09-03

Methods for Saving Arctic Sea-Ice with Cost Estimates

Method	$ Cost/Yr	$ Start Up Funding	Persistence of Start Up Funding (Yrs)	Current Scope
Tropospheric Iron Salt Aerosol Injection (ISA)	1-5 B	2 M	0.1	Global. Has potential to temporarily restore Arctic Sea Ice loss and temporarily reverse many of the most harmful climate change effects. Also removes methane and fertilizes the ocean possibly drawing down carbon dioxide.
Stratospheric Aerosol Injection (SAI)	2 - 5 B	Complete	1.5	Global. Has potential to temporarily restore Arctic Sea Ice loss and temporarily reverse many of the most harmful climate
Floating Sand	5 B	2 M	0.5	Mainly Sea-Ice. Maybe Glaciers.
Ice Thickening with Sea Water Spray	10 B	5 M	1.0	Sea-Ice only.
Marine Cloud Brightening (MCB)	100 M - 5B	10 M	0.1	Feasability is being funded for coral reef saving.
Nano-Bubble Foam		3 M	0.1	Tropical and subtropical waters

Saving Arctic Sea-Ice Triage Methods

- Iron Salt Aerosol (ISA) injection by 100 large coal burning power stations would have a global cooling effect equivalent to eliminating current global CO2 emissions of 40 GT per year. The iron only needs to be elevated to heights of 1000 meters above ground and would stay in the troposphere for only weeks which would allow for quick cessation and reversibility of its impact in the event of unintentional adverse side effects
- Stratospheric Aerosol Injection (SAI) mimics the way in which large scale volcanic eruptions temporarily cool the planet by dispersing sulfate aerosols that reflect sunlight into the stratosphere. (Mount Pinatubo is estimated to released about 15 million tons of sulfur into the stratosphere and cooled the planet by about 0.6 degrees Celsius for 15 months).
- SAI would achieve an about 1.5 Celsius average cooling across the planet relative to scenarios with 2xCO2 (that would increase average temperature by about 2.5 degrees Celsius in these models) with no average change in precipitation, and reduced variation, and maximum, global temperatures and precipitation at an estimated cost of only $ 5 billion to build 100 customized aircraft that would make about 120,000 flights per year to do this (commercial flights per year are about 40

Carbon Cycle Climate Restoration through CDR and CCSU

- CDR projects are based on either biology or chemistry, remove carbon from the atmosphere or the ocean, and sometimes also produce economically useful output(s).
- Atmospheric and oceanic carbon are in rough balance with approximately 10-year lag so that carbon must be removed from both places to reduce its concentration in either.
- The objective of Carbon Direct Removal (CDR) is to capture carbon from the atmosphere or ocean.
- The objective of Carbon Capture Sequestration and Use (CCSU) is to sequester carbon over the long-term (more than 100 years) in the land or deep ocean , or to use it in carbon-based replacement for materials like: cement, concrete, steel, aluminum, synthetic fuel, fertilizer, feed, and food.

Carbon Direct Capture from the Ocean using Biological Processes

Process	Method	Financeability	Scalability of Carbon Capture (>25 GT CO2/Yr)	Permanence (100 Yrs +)	Co-Benefits
Biological	Marine permaculture/ Seagrass, Kelp, or Macro Algae with upwelling	Potential profit though sales of kelp and commercial fishing licenses	Yes, either through sunk bio-mass or direct CCS	Yes	Food, Biofuel, other industrial products, incrased ocean biodiversity and conservation
Biological	Growing Phytoplankton with upwelling	Potential profit though sales of commercial fishing licenses	Yes, either through sunk bio-mass or direct CCS	Yes	Food, Biofuel, other industrial products, incrased ocean biodiversity and conservation
Biological	Costal Blue carbon in seagrass meadows, mangroves, salt marshes etc.	Would need public subsidies, public compliance, or charitable funding.	Very important carbon sinks but not scalable to CDR at GT level	Yes, if habitat survives	Water quality enhancement, nursuries for shell fish and fin fish, erosion protection
Biological	Ocean Downwelling	Would need public subsidies, public compliance, or charitable funding.	Unproven.	Possibly, but more reseach is needed.	NA

Table 3: Carbon Direct Capture from the Ocean using Chemical Processes

Process	Method	Financeability	Scalability of Carbon Capture (>25 GT CO2/Yr)	Permanence (100 Yrs +)	Co-Benefits
Chemical	Ocean Iron Fertilization for growing Pytoplankton (OIF)	Potential profit though sales of kelp and commercial fishing licenses	Yes, either through sunk bio-mass or direct CCS	Yes	Food, Biofuel, other industrial products
Chemical	Enhanced weathering Alkalinazation using Olivine, Limestone, or Peridodite sometimes with ocean waves	Potential profit, for example by using Olivine as sand substitute for beach nourishment.	Yes, by increasing oceans appitite for CO2. Olivine is abundant and located around the world.	Yes	Reduced Ocean acidification over time
Chemical	Direct Ocean Alkalinazation	Would need public subsidies, public compliance, or charitable funding.	Yes, by increasing oceans appitite for CO2.	Yes	Localized reduction of Ocean acidification benefiting coral reefs and other ocean life during lag of increased carbon absorption
Chemical	Using Elecrochemistry methods to forcibly remove CO2 from seawater	Unkown	Unkown	Unkown	Currently benchtop scale demos

Carbon Direct Capture from the Air Using Biological Processes

Process	Method	Financeability	Scalability of Carbon Capture (>25 GT CO2/Yr)	Permanence (100 Yrs +)	Co-Benefits
Biological	Soil/water cycle/Ag, Forestry, improved land use.	Switch to soil-carbon-sink improved water-cycle in Ag practice could be profitable but improved land use more generally would probably require public subsidies, compliance, or charitable funding.	No, scalability estimated at 1-11 GT CO2/Yr	Varies depending on situation and consistency over time.	Necessary in long-term to preserve top soil for sustainable agriculture, and green space for humans and other species.
Biological	Improved Livestock pasturing and raising also reducing methane production	Probably yes, as improved methods increase longterm health and viability of animal husbandry.	No, not that large a portion of CO2 emissions.	Varies depending on situation and consistency over time. Measured protocols have been developed, for example for California Cap and Trade law.	Necessary in long-term to preserve top soil for sustainable agriculture, and green space for humans and other species.
Biological	Bioenergy with carbon capture and storage BCCS	No, not competitive with fossil and other renewable energy sources, and competes for land use with food and forests.	No, Scalability estimated at 0-8 GT CO2/Yr	Yes	Provides carbon neutral energy

Carbon Direct Capture from the Air Using Chemical Processes

Process	Method	Financeability	Scalability of Carbon Capture (>25 GT CO2/Yr)	Permanence (100 Yrs +)	Co-Benefits
Chemical	Carbon negative synthitic limestone/building materials	Yes, is already being produced at competitive costs with current building materials	Yes, as current rock production alone is estimated at 53 GT per year.	Yes	Link to Reneable Energy and Materials Economy (REME) could power necessasry rapid scaling up of CDR
Chemical	Point source air capture and sequestration	REME for-profit co-production probably necessary for rapid scaling up. But also needs compliance and public policy support to reach scale.	Not quite, as global carbon emissions for electricity production in 2018 estimated at 22 GT per year	Yes, if sequestered in rock, aquifers, building materials or other stable products	Reduced carbon in atmosphere and REME source for building materials, fuels, fertilizers, pharmaceuticals, chemicals, and polymers.
Chemical	Direct Air Capture and sequestration	REME for-profit co-production probably necessary for rapid scaling up. But also needs compliance and public policy support to reach scale.	Yes, there is much too much carbon in the atomosphere and oceans. Estimated 1,710 GT needs to be removed to get to stable	Yes, if sequestered in rock, aquifers, building materials or other stable products	Reduced carbon in atmosphere and REME source for building materials, fuels, fertilizers, pharmaceuticals, chemicals, and polymers.
Chemical	Weathering/perido dite rock use	Unkown	Unkown	Unkown	May be more viable in oceans using shoreline wave action.

Building Material CCSU Example

- Companies like Blue Planet and CarbonCure are currently producing carbon negative, or reduced carbon, concrete, aggregate, and other building materials. This has been used in construction for the San Francisco airport.
- Estimated costs of synthetic stone at \$50/ton at capacity would be competitive with quarried stone at \$30-\$200 a ton.
- Concrete is the most widely used building material in the world as twice as much concrete is used as any other building material and construction materials (at 35 GT in 2009) make up over a third of all materials used globally by humans (other major categories are: biomass, fossil energy, and ores and industrial materials).

Ocean Iron Fertilization

- Ocean iron fertilization (OIF) was implemented in 2012 in Gulf of Alaska and (though reportedly successful) promptly shut down ostensibly due to lack of proper regulation and oversite.
- However, more recent rigorous studies suggest that the if carefully implemented and monitored, the method may have enormous potential CDR drawdown benfits.
- Estimates are that one 60 mile (100 km) square OIF “pasture” could sequester 200 million tons of CO2 per year, so that 300 of these pastures could drawdown 50 GT CO2 per year.
- This would be at a relatively at a relatively tiny implementation cost of $ 300 million a year for 10 years for ½ GT drawdown per year. It could even be profitable due to stimulation of fishing (IRR 20%), with additional public monitoring and oversite cost of $20 million per year.

Point-Source Air Carbon Capture

- Multiple point-source carbon air capture plants that capture carbon from a concentrated point source carbon emitter are currently operational and capturing carbon at scales of thousands of tons a year.
- Global-Thermostat, a company founded and run by two academics Chichilnisky and Eisenberger who believe that rapid scaling up of DAC (Direct Air Capture) and CCSU is critical to solving the climate crisis, has in collaboration with Exon-Mobile built two plants that capture 3,000 – 4,000 tons of CO2 a year and is scaling up to a 50,000 ton CO2 a year plant.
- The plants are designed to added to existing natural gas fired electric power generators to draw down carbon from their flue emissions and from the air when the gas plant is operating using either using excess heat generated by the power plants, and exclusively from the air using concentrated solar energy when the gas plant is not operating with a net carbon negative outcome.
- The idea behind these plants is to use continued natural gas fossil fuel use to rapidly scale up CCSU to advance toward an REME (Eisenberger, 2020).

Direct Air Capture (DAC) from Ambient Air

- Klaus Lackner, who was the first to conceive of and prove that DAC is feasible, and his team, have developed “mechanical trees” that can remove carbon from the atmosphere much faster than ordinary land or sea based organisms.
- Just like real trees, Lackner’s mechanical trees capture carbon passively by letting the wind blow it through them, reducing energy costs per ton of carbon capture to below $100 per ton and are not limited by access to a carbon rich point-source.
- One tree can draw down almost 1 metric ton of CO2 a day, and a cluster of 1,200, like the one that Silicon Kingdom Holdings, the company that Lackner and ASU are working with, is planning to build in California, 36,500 metric tons a year.
- For comparison, a normal tree removes approximately 48 pounds CO2 a day, or almost 46 years to remove 1 metric ton. Large scale “farms” of 120,000 trees are estimated to be able to 4 million tons of C02 annually and will occupy a land area of about one square mile. 250 of these farms could thus remove a gigaton of CO2. This is critical as forests of trees, bamboo or Buffalo Grass can also potentially draw down vast amounts of carbon but over much larger areas.

Climate Policy for a Renewable Energy and Materials Economy (REME)

- The climate crisis needs to be turned into the climate opportunity for a fundamental transformation of the forces of production from “hunter-gatherers” of carbon-based fossil fuel energy and materials and one-way utilizers of the oxidization part of the carbon cycle, to “cultivators” of a “Human Designed Carbon Cycle Run by Renewable Energy” (HDCCRRE) (Eisengerger, 2020).
- Up until now humans have relied on nature to close the carbon cycle for reuse through photosynthesis and sequestration through weathering mineralization and ocean sinks in a process of Carbon Capture Sequestration and Use (CCSU).
- But we have reached the limits of our hunter-gatherer unidirectional utilization of carbon-based energies and materials pillaging of nature, as our planets atmosphere and oceans can no longer absorb the excess carbon imbalance that we have created.

Carbon Sequestration and Use

- Sequestration methods include mineralization, geological sequestration in basalt rock formations, sequestration in saline aquafers, or in enhanced oil recovery wells.
- It has shown for example that about 72% of CO2 captured by CarbFix and injected into Basalt rock formations mineralized within about 2 years .
- As Basalt rock, saline aquafers, and oil wells are widely available, there is not a near term problem with sequestration of even thousands of gigatons of carbon.
- Carbon use methods are discussed below.

Closing the Carbon Cycle with CCSU

- On the *use* side, nature is forcing us to close the carbon cycle by taking over the production of carbon-based renewable “fuel” in a process of human- designed “photosynthesis” of synthetic hydro-carbon fuel production using renewable, currently mostly solar, energy, and human-designed renewable materials (initially mostly building materials: concrete, steel, and aluminum) from carbon fibers, graphene, and polymer composite building materials and renewable energy.
- Interestingly, one of many possible methods for addressing the other major link in this transition, biological or electro-chemical capturing of hydrogen using manageable levels renewable energy may be through closing the cycle for methane, the second largest GHG.
- On the *sequestration* side, As we are unlikely in the to be able to use enough of the stock of accumulated carbon that we need to remove from the atmosphere and ocean at a rapid enough pace to stabilize planetary climate, we are going to have to assist nature in sequestering it for long periods of time.

REME Potential for Climate Management and for Human Prosperity and Greater Equity

- Though we currently have dumped more carbon that we can possibly use in the atmosphere and ocean, in the future we may be able to adjust our use and sequestration, or carbon cycle management, in order to stabilize our climate and avoid geological "glacial" and "hot-house earth" periods driven by Milankovic and carbon cycle events .
- At some point we may be interested in "storing" carbon in an accessible way that will make it easy to utilize, but right now, to avoid catastrophe we need to remove and sequester what we cannot use in whatever way possible as quickly as we can.
- Sustainable energy use and social and economic transformations that increase environmental justice and overall equity and opportunity are central to the GGND vision.
- REME transformation from one-way carbon combustion and materials use "hunter gatherer" industrial civilization, to more complete HDCCRRE "cultivator" REME civilization, is possibly the opening to a world free of scarcity that allow an induce greater human social relations of production progress toward a democratic socialism or even democratic communism.

Practical Policies to Address Climate Crisis within a Climate Dictated Timeframe I

- Restrict and quickly eliminate further "carbon dumping" by setting up a mandatory "dumping fee" or "cap and trade" market for all carbon dumped into the atmosphere or ocean with a cap that very rapidly goes to zero.
- A global cap and trade market with equitable, net-emissions, caps for all countries based on responsibility and capacity as proposed for example by the Greenhouse Development Rights Framework policed by national governments would address most of the regulation and governance issues brought by critics (Hahnel, 2012).
- Hahnel's major point also applies to Article 6 of the Paris Agreement: national carbon emissions can be accurately measured; individual countries could be held responsible for their emissions regardless of whether traded "carbon offsets" (this issue is less likely to occur with "carbon removal" trading) are real or not.
- A global cap and trade market like this would also increase the efficiency and scope of drawing down GHGs and lead to a large transfer of funding and investment to developing countries. Similar, national and state public compliance, and private voluntary carbon removal markets, can and are critical to developing protocols and creating markets for CCSU.

Practical Policies to Address Climate Crisis within an Urgent Climate Dictated Timeframe II

- Since even a “zero cap on carbon emissions” is not adequate, we need to also directly subsidize and expand the funding of large-scale Carbon Direct Removal (CDR) and Carbon Storage and Sequestration, and Use (CSSU) markets.
- Sources of funding for this could be the unique power of the US federal government to directly pay for global GHG drawdown by issuing and lending dollars (as in the Marshall Plan), additional carbon high-income and wealth, and rentier, taxes that would stimulate GGND economic development and use these funds for CDR by using carefully monitored public or private carbon sequestration certificates and “dump sites” or sequestering facilities where this could be constructed.
- Position governments and private industry as buyers of carbon negative products, and of stored and sequestered carbon . A keyway to do this would be to pass laws and regulations mandating the use of carbon neutral or zero negative construction materials, fertilizer, fuel, feed stock, food and other goods and services.

Conclusion

- We need to turn carbon drawdown, including CDR and CSSU, into major profit opportunities use public policy to directly fund GGND REME and CCSU to address climate change and global and economic equity and real (rather than rentier) production of goods and services.
- As Lackner has pointed out, minimum price for ambient (atmospheric or oceanic) carbon drawdown would become the effective “carbon tax” in a publicly enforced no carbon dumping compliance regime, and the public subsidy price for large-scale additional carbon drawdown and climate restoration.
- Thus, the more efficient DAC CDR becomes, the more pressure on point-source emitters like for-profit fossil fuel producers and users, who currently have an incentive to stall and delay and deny, to rapidly develop less costly (than DAC CDR) zero emissions technologies.
- We need to immediately fund, pilot, and deploy Arctic Sea-Ice saving climate triage to avoid crossing the first critical Arctic Sea-Ice loss global climate tipping point, and utilize large scale public infrastructure and jobs program roll-outs coupled with existing competitive for-profit markets embedded in government compliance regulations and taxes and subsidy regimes to incentivize the development of a competitive and efficient CDR and CCSU for progress toward the REME economy of the future.