The Climate Crisis and 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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Abstract: A Global Green New Deal (GGND) that Includes Arctic Sea-Ice Climate Triage and Carbon Cycle Climate Restoration, and that, following (Eisenberger, 2020), would move us toward a Renewable Energy and Materials Economy (REME), is necessary to turn our current civilization and species threatening climate crises into an opportunity to stabilize our planet's climate and advance to a new more equitable and prosperous stage of human development. Immediate, potentially catastrophic, global climate impacts of imminent Arctic Sea-Ice loss, the first global climate "tipping point", are reviewed, and practical and efficient potential climate triage methods for avoiding this are summarized. Longer-term Direct Carbon Removal (CDR) and Carbon Storage, Sequestration, and Use (CCSU) methods that would move us toward long-term carbon cycle climate *restoration* are presented. A general reframing of climate policy, and specific GGND policy proposals that include Arctic Sea-Ice climate *triage* and carbon cycle climate *restoration,* that would rapidly move us toward a REME and avoid increasingly catastrophic climate impacts are proposed.

I. Introduction

A Global Green New Deal (GGND) is a critical transformative goal that could be funded by the US alone by creating dollars at roughly the 2008-2011 rate (that though historic is considerably less than the 2020 rate) for almost thirty-years (Baiman 2020).[1] 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, certainly Arctic Sea-Ice climate triage, could cost less than fighting Covid-19 (King and Parnell 2020).[2] But a GGND needs to include practical climate triage and restoration.

Evidence presented in Figure 1 below suggests that mitigation (or "Green House Gas" (GHG) emissions reduction) and *adaptation* (to increased global warming) will be inadequate to prevent ever greater climate catastrophe if urgent climate triage is not implemented to prevent the Arctic Sea-ice from melting, in addition to rapidly scaling up carbon cycle restoration, or negative carbon emission, through Carbon Direct Removal (CDR) and Carbon Capture, Sequestration, and Use (CCSU)).[3]

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[1] Over ten years from 6/2009 to 6/2019 the Fed stock of T-Bills increased by $1.7 T (Baiman, 2020: 3). Over eight months from 2/12/2020 to 10/28/2020 the Fed stock of T-Bills increased by $2.1 T, see: https://fred.stlouisfed.org/series/TREAST (downloaded 11/23/2020). As the Fed is legally required to turn its profit (minus negligible operations costs) to the Treasury, this represents money created by the Fed for Treasury.

[2] King and Parnell also call for immediate climate *restoration* including Direct Air Capture, in addition to *mitigation* and *adaptation*.

[3] In 2010, 76% of GHG emissions were carbon, 16% methane, 6% nitrous oxide, and 2% F-gases: https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data. About 50% of carbon released into the atmosphere will be removed within 30 years, a further 30% within a few centuries, but the remaining 20% may remain for many thousands of years https://www.ipcc.ch/report/ar4/wg1/ . As methane and nitrous oxide are less

Figure 1 shows that since 1990 global greenhouse gas (GHG) emissions (and thus global warming) have continued to trend upward despite numerous international GHG mitigation agreements and commitments. The 1.8 Celsius projected trend line in the figure are based on the (UNEP 2020, Table ES.1) estimate that global emissions in 2030 must be about 35 GtCO2e to have a 66% chance of keeping global warming below 1.8 degrees Celsius, or "well below" 2.0 degrees Celsius, as stipulated in the 2015 Paris Accord (UNCCa 2021).[4] However, as of the end of 2020, updated and more "ambitious" NDC commitments for 75, or almost 40%, of the 197 countries that signed the Paris Agreement, representing 30% global GHG emissions, would reduce global GHGs in 2010 by 1% less in 2030, to 46 GtCO2e based on Figure 1 data (UNCC 2021b). It therefore appears highly unlikely that global warming from GHG accumulation will be kept well below 2.0 degrees Celsius unless Paris Accord voluntary "Determined Contributions" (NDCs) are dramatically increased, or a more stringent "conditionally mandatory" update of the Kyoto global cap and trade system that includes support for a rapid scale-up of negative emissions technologies, is implemented at the Glasgow COP26 (see below).

These repeated failures to adequately reduce global GHG emissions have undoubtedly contributed to the recent official acknowledgment in multiple reports of the necessity of carbon removal, or negative emissions, to keep well below the (too high given the melting Arctic, see Figure 2 below) 2.0 degrees Celsius GHG induced global warming Paris Accord guardrail (IPCC 2018) (National Academy of Sciences 2019). Acknowledgements that are also important for correctly framing the GHG climate change problem in stock-capacity carbon use and waste-management carbon-cycle closure terms rather than exclusively as a flow-reduction problem (Eisenberger 2020).

Figure 1: The Failure of Global Climate Mitigation and Adaptation Policy

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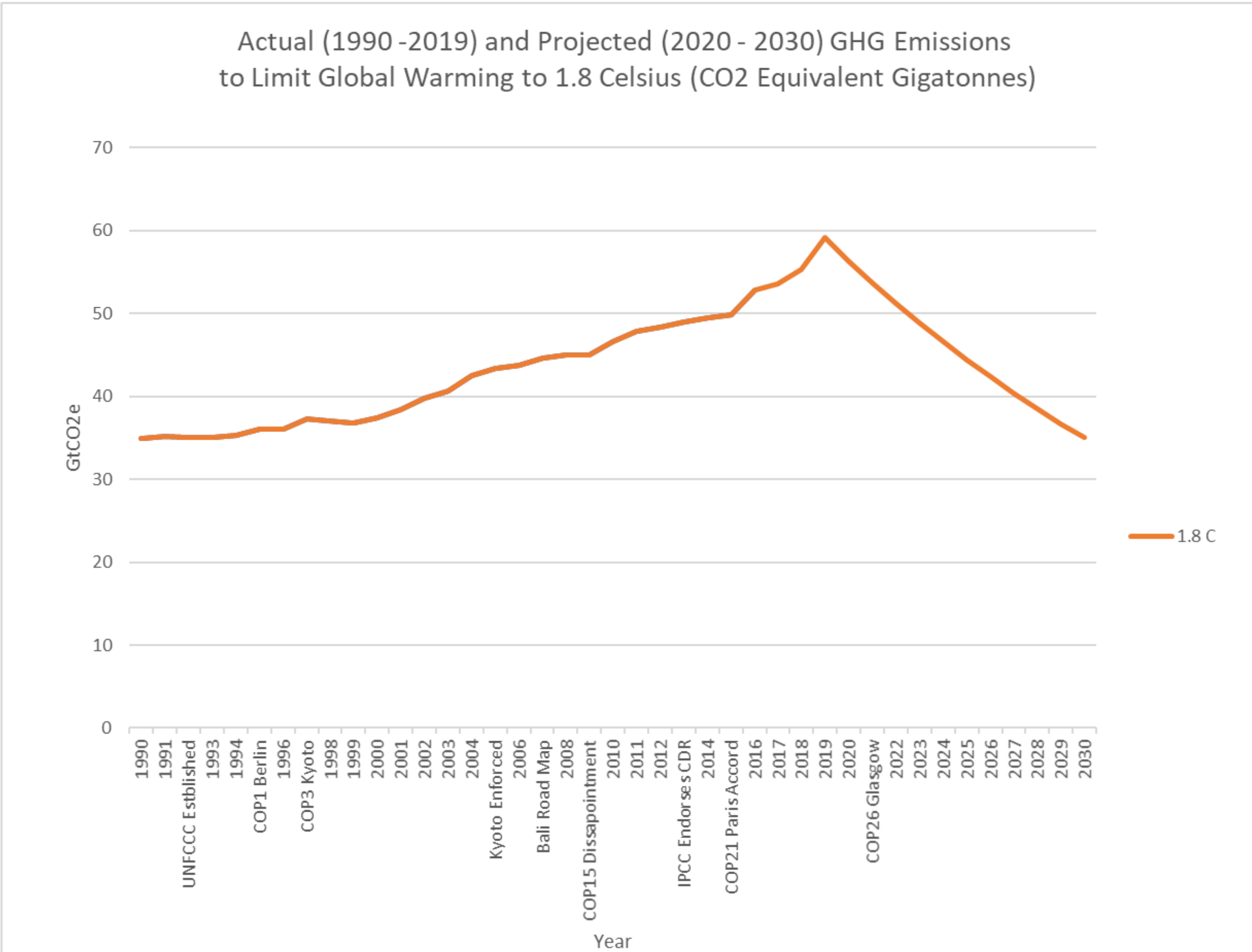
abundant and removed more quickly (average lifetime 8.4 and 120 years respectively, the focus of GHG climate change analysis (in this paper and others) is on carbon https://www.ipcc.ch/site/assets/uploads/2018/03/TAR-04.pdf .

[4] Achieving 35 GtCO2e emissions levels by 2030 requires average annual reductions of 4.65% a year for 11 years from 2019 estimated emissions of 59.1 GtCO2e as displayed in Figure 1.



Sources: Author's calculations from (Ritchie and Roser 2020) data for 1990 – 2015, (UNEP 2018) (UNEP 2019) (UNEP 2020) data for 2016-2019 and 2030 1.8 Celsius estimate, and y-axis timeline from (Chichilnisky and Bal 2019, p. 132-3).

The Climate Crisis will also 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 including efforts to: a) stop despoiling and destroying natural habitats, b) work on medium term soil and water-cycle climate regeneration (Baiman 2020), and c) reduce human population encroachment into hitherto distant viral and bacterial pools that increases the incidence of global pandemics. But 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. This should not be viewed as a political or moral failure of our species. Fossil fuels account for 84% of the world's energy and a large share of raw material inputs for much of modern industrial civilization (BP 2020, Table 1 p. 4). 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 accounting for 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 substitutes for steel and aluminum, as well as substitutes for feed, fertilizer, and many other materials, using carbon from the air, currently exist or are being developed. But especially for developing countries, and particularly those who are dependent on fossil fuel or natural resource exports - often produced by public companies, there may be no other viable options, and even if were available rebuilding or readapting a [5] As discussed below, a "Renewable Energy and Materials Economy" (REME) economy will develop these alternatives, but not overnight.

In fact, the pervasive GGND "carbon-free", as opposed to a "net-carbon free" or "carbon cycle closing", economy framing (Zachs 2019) may have in some cases become an obstacle to practical progress in making climate change an opportunity instead of a problem. The goal after all is not an economy free of carbon, or "carbon purity", but rather to reduce and drawdown "fugitive carbon" from the atmosphere and ocean, as carbon is not a pollutant but a primary molecule of life (McDonough 2016). There is no question that the world economy needs to achieve *net* "deep decarbonization" in the long run, but in the short run rapidly reducing atmospheric carbon *and* equitably raising global living standards may require the continued use of fossil fuels, for example for negative emissions natural gas fired electric power generation technology (see below).[6]

In summary, climate change is fundamentally a closing the carbon cycle (REME) reuse problem, and as it is likely to be impossible to reuse as much carbon as we need to sequester in the coming decades, also a carbon sequestering waste management problem. In the short run the climate can and must, due to the time urgency, be addressed within existing capitalist social and economic *systems* and with current and evolving infrastructure and technologies including

[5] This was driven home to me by two incidents: a) the President of Ecuador offering to not exploit newly discovered oil reserves in the Amazon rain-forests if the international community would reimburse Ecuador for forgone oil earnings, and after getting no response, moving ahead with oil extraction (Goldman, 2017), b) Norway (one of the most social democratic, environmentally responsible, and wealthiest (per-capita) countries in the world) going ahead with exploitation of newly-discovered north sea-oil reserves using "green" technologies (Kottasovana, 2020). If Norway cannot resist cannot fossil fuel exploitation, I doubt that any other major country in the world will be able to.

[6] Estimates suggest that atmospheric warming, from the elimination of fossil fuel SO2 aerosol cooling, could offset much of the initial cooling impact of GHG emissions reduction from net decarbonization (Samset et al 2018). If this is the case, though there is no question that a full transition to renewable energy is necessary in the long-run, it may be wise to either couple this with substitute tropospheric cooling aerosol methods such as "Marine Cloud Brightening" (MCB) and "Iron Sale Aerosol" (ISA), and continued net-carbon negative fossil fuel use (such as Global thermostat's (GT) carbon Direct Air Capture (DAC) from natural gas power generation technology) in the immediate short-run transition period, see Section's III and IV below.

emergency climate triage. But in the long run the climate *crisis* becomes a climate restoration opportunity to transform the forces of production in ways that reduce or eliminate energy and materials scarcity and allow for the possibility of a more prosperous and just democratic socialist human civilization in the future.

III. Saving Arctic Sea-Ice Climate Triage

Arctic Sea-Ice melting is the first major climate tipping point (Lenton et al 2020). Melting Arctic ice, unlike the Greenland and Antarctic ice sheets, is not voluminous enough to cause massive sea level rise, so this is not the major effect that makes this a climate tipping point. Rather, an ice free summer Arctic will abruptly accelerate the frequency of catastrophic climate change and the risk of crossing other catastrophic tipping points, as polar ice is a critical component of the global climate system (Lenton et al, 2020). For example, Arctic sea-ice melting would have a global warming impact roughly be 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 (Pistone et al, 2019) that would blow through the global carbon budget.[7]

As can be seen in Figure 2 below the exponential, log, and 2nd order polynomial, fits for September Arctic Sea-Ice go to zero in 2025, the linear fit in 2027, and the Gompertz fit (with the highest displayed R2) appears to asymptote with the horizontal axis outside of the plot sometime between 2030 and 2040. In other words, climate data is telling us that if current trends continue there will be a zero "blue ocean" September Arctic sea-Ice event by 2025-2040. Similar trends for other months suggest that complete Arctic sea-ice melt will occur in following years.

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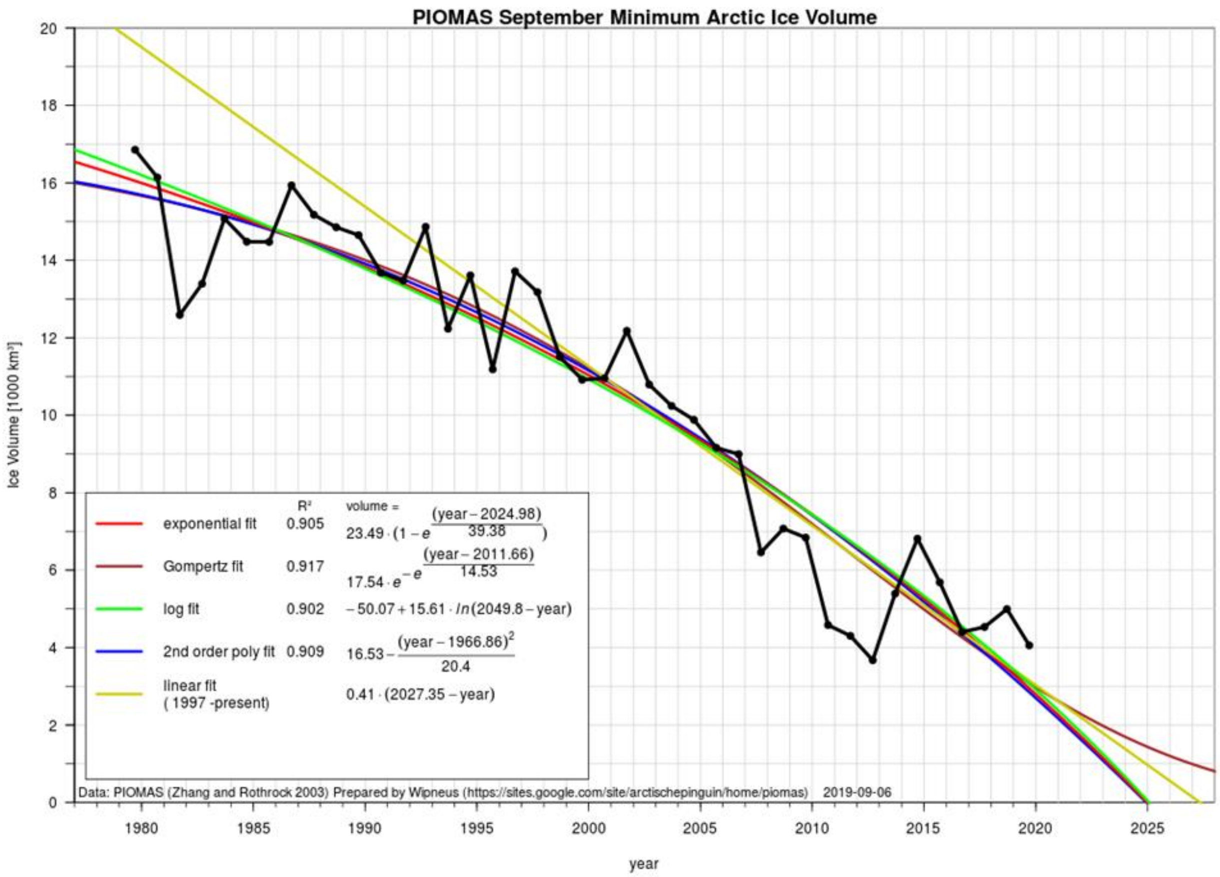
[7] The authors use the approximate formula f = (5.35 W/m^2) ln(x/R) were f is radiative forcing relative to R, and x atmospheric concentration (Pistone et al, 2019, p. 7479). For a given R and f this implies that: $x = Re^{(\frac{f}{5.35})}$. The authors used f=0.71 W/m^{2,} which they estimate is increased radiative forcing from 1979 to an ice-free Arctic, but used 2016 400 CO2 ppm for R, to get 456.8 CO2 ppm, or an increase of 56.8 CO2 ppm, from Arctic sea ice melting. They then multiply this by 7.77 and divide by 0.44 to get 1002.5 increased GtCO2e2. By dividing this by average current emissions of 40 GT they derive an estimate of 25.1 years of GHG emissions at current levels. However, they estimate 0.5 W/m^2 not 0.71 W/m^2 as radiative forcing from 2016 (Pistone et al 2019, p. 7476). Correctly starting with f = 0.5 W/m^2 and using the same procedure as above produces an estimate of 17.3 years of 40 GT emissions from 2016.

Figure 2: September Minimum Arctic Sea-Ice Volume 1979-2020



Sources: Graph prepared by Wpneus, based on methodology of (Zhang and Rothrock, 2003) using US Dept. of Energy "Climate Model Intercomparison Project" (CMIP) data. Accessed at: https://sites.google.com/site/arctischepinguin/home/piomas

Proposed triage methods for saving the Arctic sea-ice include the following, see Table 1 below.

Table 1: Methods for Saving Arctic Sea-Ice with Cost Estimates

Method	$ Cost/Yr	$ Start Up Funding	Persistence of Start Up Funding (Yrs)	Current Scope
Stratospheric Aerosol Injection (SAI)	2.25 B	3.6 B	7	Global. May be able to temporarily slow and restore Arctic sea Ice loss and temporarily reverse many of the most harmful climate change effects.
Marine Cloud Brightening (MCB)	100 M	10 M	0.1	Local. May be able to temporarily slow and restore Arctic sea ice loss, and slow or temporarily reverse harmful climate change effects. Feasiibility research for saving coral reefs currently being funded.
Tropospheric Iron Salt Aerosol Injection (ISA)	50 M	2 M	0.1	Local. May be able to temporarily slow or restore Arctic sea Ice loss, draw down methane and carbon, fertilize the ocean, reduce ocean acidification, and slow or temporarily reverse harmful climate change effects
Floating Sand	5 B	2 M	0.5	Local. May be able to temporarily slow or restore Arctic sea ice, and other ice loss.

Sources: (Fiekowsky et al, 2019: Table 3, p. 25) (Smith and Wagner, 2018) (Latham et al 2012) (Oeste et al, 2017) (Field et al, 2018)

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 (Watson, 1997). Mount Pinatubo, for example was estimated to have released about 15 million tons of sulfur into the stratosphere and cooled the planet by about 0.6 degrees Celsius for 15 months (NASA, 2011). A leading current SAI proposal is estimated to have a capital cost of $3.6 billion over 7 years and operational cost of $ 2.25 billion a year over 15 years to develop and deploy a fleet of 14 customized aircraft that would disperse enough SO_2 to offset about half of projected global heating from a projected date forward (Smith and Wagner, 2018). Slowly ramped up application SAI is estimated at peak application to reduce average global temperature by about one degree Celsius and restore global mean precipitation closer to its preindustrial levels (MacMartin et al 2017). SAI has been studied and debated more than any other climate triage method. Two key concerns that have been raised are that SAI could damage the Stratospheric Ozone layer and could not be quickly terminated in the event of unforeseen adverse effects. However, significant Ozone damage from potential SAI has not been established and may be avoidable by using calcite instead of sulfate aerosol (Keith et al, 2016).

"Marine Cloud Brightening" (MCB) is another relatively well-studied method. MCB proposes to increase the reflectivity of low-lying marine stratocumulus clouds by spraying them with aerosol produced from sea water, possibly using a fleet of remotely controlled wind driven spray vessels (Latham et al 2012). SAI and Marine Cloud Brightening (MCB) are highlighted as examples of methods that should be included in a comprehensive federal Solar Radiation Management (SRM) research program proposed in a recent National Academy of Science report (National Academy of Sciences, 2021).[8] These methods have also attracted significant federal and private non-profit funding (Flavelle 2020).

Tropospheric Iron Salt Aerosol (ISA) injection is a less studied, but potentially practical and risk free, SRM method that mimics the role that natural iron dust storms, and anthropogenic coal fired power plant and industrial iron emissions, have played in fertilizing the oceans and cooling the planet. According to one estimate, adding ISA precursor aerosol to the emissions of 100 large coal burning power stations would have an aggregate global cooling effect equivalent to eliminating current global CO2 emissions of approximately 40 Gt per year. The iron salt aerosol would be elevated to heights of 1000 meters above ground and would stay in the troposphere for only weeks. It would likely have no impact on, the much higher up, stratospheric ozone, and could quickly be terminated in the event of unintentional adverse effects. The iron aerosol would also likely interact with and reduce methane and (harmful) ozone in the troposphere and stimulate ocean fertilization and carbon sequestration when it falls into the ocean (Oeste et al, 2017, p. 33).

IV. Carbon Cycle Climate Restoration through CDR and CCSU

CDR projects utilize chemistry or biology to remove carbon, directly from point source or ambient atmospheric sources, or indirectly from the atmosphere by interacting with the ocean or land, and sometimes also produce economically useful outputs. The objective of CDR is to capture carbon from the atmosphere, and the objective of CCSU is to sequester this carbon over the long-term (more than 100 years) in the land or deep ocean, or to use it to produce synthetic materials like: fuel, cement, concrete, steel, aluminum, rugs, fertilizer, feed, and food

[8] A third SRM example discussed in the National Academy of Sciences report, Cirrus Cloud Thinning (CCT), is less studied and more uncertain.

(Wilox et al 2021) (Eisenberger 2020). Below are short discussions of three existing methods for doing this:

Numerous companies like Blue Planet[9] and CarbonCure[10] are currently producing carbon negative, or reduced carbon, cement, aggregate, and other building materials. Carbon negative concrete has been used in construction for the San Francisco airport. Estimated costs of synthetic stone at $50/ton at capacity are competitive with quarried stone at $30-$200 a ton (Fiekowsky, 2020, p. 20). Concrete is the most widely used material in the world, as twice as much concrete is used as any other building material (Gagg, 2014), 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) (Eisenberger, 2020, p. 21).

Multiple point-source, or point-source related, carbon capturing plants are currently operational and capturing carbon at scales of thousands of tons a year. Global-Thermostat, a company founded and run by two academics Graciela Chichilinsky and Peter Eisenberger, has built two plants that capture 3,000 – 4,000 tons of CO2 a year and is currently collaborating with Exxon Mobil to build a scaled up 50,000-ton CO2 a year plant (Soltoff, 2019) (Chichilinsky and Bal, 2019). The plants are designed to be added to existing and new natural gas fired electric power generators to draw down carbon from the air when the gas plant is operating using excess heat generated by the power plants, and from the air using concentrated solar energy when the gas plant is not operating - in both cases with a net carbon negative outcome. These carbon negative plants would facilitate continued use of existing fossil fuel infrastructure for DAC and CCSU to advance toward a REME (Eisenberger, 2020)

Klaus Lackner (reportedly the first person to prove that Direct Air Capture (DAC) is feasible (Lackner, 2012)) and his team, have developed "mechanical trees" that reportedly can remove carbon from the ambient air much faster than ordinary land or sea-based organisms. Just like real trees, Lackner's mechanical trees capture carbon from the air passively by letting the wind blow through them and rely on energy from sorbent moisture swings in dry air to capture CO2, reducing energy costs per ton of carbon capture to below $100 per ton. The mechanical trees are also not limited by access to, or proximity to, a point-source carbon emitter. A cluster of 1,200 mechanical trees, like the one that Silicon Kingdom Holdings - the company that Lackner and ASU are working with - is planning to build in California, are estimated to draw down about 36,500 metric tons a year (ASUNow, 2019). For comparison, a normal tree removes about 48 pounds of CO2 a year, a rate that is about 1,400 times slower.[11] Large scale "farms" of 120,000 mechanical trees are estimated (with some economies of scale) to draw down roughly 4 million tons of C02 annually and occupy a land area of about one square mile (ASUNow, 2019a), so that 250 of these farms could remove about a gigaton of CO2. This is critical as forests of trees,

[9] https://www.blueplanet-ltd.com/
[10] https://www.carboncure.com/
[11] http://www.tenmilliontrees.org/trees/

bamboo or Buffalo Grass can also potentially draw down vast amounts of carbon but over much larger areas and time periods.[12]

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

The climate crisis can be considered a climate opportunity for a fundamental transformation of the forces of production from being based on the work of "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) (Eisenberger, 2020). Until now humans have relied on nature to close the carbon cycle for reuse through photosynthesis, and sequestration through weathering mineralization and ocean sinks. But we have reached the limits of our hunter-gatherer unidirectional utilization of carbon-based energies and materials pillaging of nature, as our planet's atmosphere and oceans can no longer absorb the excess carbon imbalance that we have created.

As we are unlikely 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 also going to have to assist nature in sequestering it for long periods of time. Carbon sequestration methods include mineralization, geological sequestration in basalt rock formations, sequestration in saline aquafers, or in enhanced oil recovery wells. It has been shown for example that about 72% of CO2 captured by CarbFix, and injected into Basalt rock formations, mineralized within about 2 years (Pogge von Standmann et al, 2019). As Basalt rock, *saline* aquafers, and oil wells are widely available, there appears to be no near-term problem with sequestration options at levels necessary to restore a stable climate.[13]

Policies necessary to practically address the climate crisis within a climate dictated timeframe include the following:

a) Large-scale carbon markets should be directly subsidized and supported by using public policy to directly fund CCSU to address global economic equity and real (rather than rentier) production of goods and services (Baiman, 2020). 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); and additional carbon, and high-income and wealth rentier, taxes (Baiman, 2020). These funds could be used to stimulate GGND targeted "climate justice" economic development by supporting CDR and CCSU projects (Baiman, 2020). Similarly, creating carefully monitored public or private carbon sequestration certificates and "dump sites" or sequestering facilities where carbon could be sequestered, prioritizing underdeveloped and climate crisis affected locations.

[12] Nature based CCSU in the ocean is limited less by space than by essential mineral nutrients.
[13] My (author's) calculations from recent data suggest that about 1,710 Gigatons of CO2 would need to be removed from the atmosphere to get back to 1989 level of 353 ppm (Schuckmann et al., 2020).

b) Public and private compliance markets for carbon negative products, and for carbon and carbon-based materials should be created by passing laws and regulations mandating the use of carbon neutral or negative construction materials, fertilizer, fuel, feed stock, food and other goods and services.[14] The 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 and other forms of Carbon Direct Removal (CDR) become, the more pressure on point-source emitters like for-profit fossil fuel producers and users, who currently have an incentive to stall, delay and deny, to rapidly develop less costly (than DAC CDR) carbon-zero or carbon-negative negative facilities like the Global Thermostat DAC from natural gas power plant technology discussed above.

c) A global mandatory net carbon "dumping fee" or "cap and trade" market for GHGs with a cap that very rapidly goes to zero, based on responsibility and capacity[15], and enforced by national governments*.* A revived global Emissions Trading System (ETS) would increase the efficiency and scope of drawing down GHGs and lead to a large transfer of funding and investment to developing countries, as occurred under the Clean Development Mechanism (CDM) of the Kyoto Protocol, and also address the regulation and governance issues raised by critics (Chichilnisky and Bal, 2019 (Hahnel, 2012). Hahnel points out that as national GHG emissions can be more accurately estimated than those of many specific transactions, individual countries can be held responsible for their emissions regardless of whether traded "GHG offsets" are real or not – an issue that is less likely to be a problem for carbon capture than for GHG mitigation. Alternatively, a replacement (or additional) global cap and trade market for CO2 extracted from the atmosphere or ocean, and a "Clean Investment Mechanism" (CIM) to support investment in Negative Emissions Technologies (NET) in developing countries, analogous to the Kyoto CDM, has recently been suggested (Chichilnisky, 2021 p. 24-5). A CIM would foster profitable investment in Negative Emissions Technology (NET) in developing countries to achieve carbon capture goals and would comply with the 1997 Byrd Hagel law stipulating that any US climate response grow the economy. If the CIM included social floor regulations, including: wages, working conditions, and corporate income taxes, it could serve to leverage capitalist incentives to rapidly scale up production of CDR, a public good, and raise living standards in developing countries (Baiman 2017, Chap. 8).

Arctic Sea-Ice saving climate triage must be immediately researched, piloted, and deployed to avoid crossing the first critical Arctic Sea-Ice loss global climate tipping point. Large scale public infrastructure and jobs program rollouts coupled with existing competitive for-profit markets embedded in government compliance regulations and taxes and subsidy regimes are necessary to incentivize the development of CCSU for the REME economy of the future. Sustainable

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[14] For example, the two compliance offset protocols for California's cap and trade law that primarily address carbon (Urban forest, and US forest) address carbon *mitigation* or natural drawdown: https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/compliance-offset-protocols .

[15] As proposed for example by the Greenhouse Development Rights Framework: http://gdrights.org/about/

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 us to move toward a democratic socialism or even democratic communism.

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